

Sander, Julia; Schumann, Paul; Richter, David; Specht, Jule

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## Personality Psychology

# Leisure Activities as a Driver of Personality Development? A Random-Intercept Cross-lagged Panel Model Across 13 Years in Adulthood

Julia Sander<sup>1 a</sup>, Paul Schumann<sup>2</sup>, David Richter<sup>1</sup>, Jule Specht<sup>3</sup>

<sup>1</sup> Department of Educational Science and Psychology, Freie Universität Berlin, Berlin, Germany; German Institute for Economic Research (DIW Berlin),

<sup>2</sup> Department of Psychology, Humboldt-Universität zu Berlin, Berlin, Germany, <sup>3</sup> Department of Psychology, Humboldt Universität zu Berlin, Berlin, Germany; German Institute for Economic Research (DIW Berlin)

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Repeated experiences and activities drive personality development. Leisure activities are among the daily routines that may elicit personality change. Yet despite the important role they play in daily life, little is known about their prospective effects on personality traits and vice versa. The objective of this study was to examine the extent to which within-person changes in leisure activities lead to prospective changes in personality traits, and whether changes in personality elicit prospective changes in leisure activities. We applied random-intercept cross-lagged panel models (RI-CLPM) to four waves of 13-year longitudinal data (2005–2017) from the German Socio-Economic Panel Study (SOEP) for the sample as a whole ( $N = 55,790$ ) and for three specific age groups (young, middle-aged, and older adults). We examined between-person associations and within-person auto-regressive effects, correlated change and cross-lagged effects for Big Five personality traits (i.e., openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism) with self-reported frequency of leisure activities (i.e., physical activities, socializing, volunteering, political activity, artistic and musical activity, going out) and overall participation in leisure activities. At the between-person level, leisure activities and overall participation were most strongly associated with openness to experience. At the within-person level, we found reciprocal effects of extraversion only with overall participation in leisure activities and socializing. We found unidirectional within-person cross-lagged effects between leisure activities and personality traits and vice versa. Some effects were age-group-specific only. These findings suggest that leisure activities that are associated with certain traits at the between-person level are not necessarily those that trigger change in the respective personality trait. We discuss our findings based on the TESSERA framework for personality development. We conclude that the specificity of an experience or behavior and its corresponding trait is essential for personality development and should be subjected to further research.

## Introduction

Personality has very concrete implications for many life domains such as health, mortality, relationship success, educational and occupational attainment, income, and job satisfaction (for an overview, see Soto, 2019). Because personality is also subject to change, there is great interest in understanding patterns of development and mechanisms of change in personality (Aschwanden & Allemand, 2020; Bleidorn et al., 2019).

In line with recent theories on personality change and stability (Roberts, 2018; Wagner et al., 2020; Wrzus &

Roberts, 2017, for an overview, see also Specht et al., 2014), we hypothesized a gradually unfolding effect of leisure activities on personality and vice versa. We thus assumed that changes in participation in leisure activities may be a source of individual differences in personality development across the lifespan.

In this study, we investigated transactions between overall *participation* in leisure activities and six specific *leisure activities* with changes in the Big Five personality traits (John & Srivastava, 1999) over time in adulthood. For this purpose, we used data from 55,790 individuals who participated in the annual SOEP study over a period of 13 years.

<sup>a</sup> julia.sander@fu-berlin.de

## Personality Development Across the Lifespan

Measures of personality traits show both continuity and change throughout adulthood (Roberts et al., 2006). The rank-order consistency of personality traits—which reflects the placement of individuals within a population—is relatively but not completely stable across the lifespan (Damian et al., 2019; Roberts & DelVecchio, 2000; Specht et al., 2011). Personality therefore does change. It develops at different ages marking key transitions in the life course from early adulthood to old age. In young and middle adulthood, personality generally develops towards greater psychological maturity: on average, neuroticism decreases, while agreeableness and conscientiousness increase. Sociability, a facet of extraversion, tends to decrease on average with age, while social dominance, another facet of extraversion, tends to increase. Openness to experience shows a curvilinear pattern of mean-level change, with increases in early adulthood and decreases later in life (e.g., Lucas & Donnellan, 2011; Roberts et al., 2006; Specht et al., 2011; for reviews on personality mean-level change, see Bleidorn & Hopwood, 2019; Specht et al., 2014).

Not all individuals change in the same ways with age, however. There are also substantial individual differences in change throughout the lifespan, and not everyone follows the aforementioned mean-level trends (Bleidorn et al., 2018; Schwaba & Bleidorn, 2018).

## What Drives Personality Development?

Most theoretical frameworks agree that personality can be shaped by *biological factors*, e.g., genetic influences or health issues, as well as *environmental factors*, e.g., social roles, normative life transitions, or major individual life events. There is empirical evidence that both genes and life experiences play a role in personality stability and change (Bleidorn et al., 2014; Briley & Tucker-Drob, 2014). Other factors such as time, role scripts, and individuals' own active involvement appear to be sources of change in personality traits (see Specht et al., 2014).

Despite differences in details, recent theoretical frameworks (Roberts, 2018; Wagner et al., 2020; Wrzus & Roberts, 2017) broadly describe personality change as a bottom-up process: Recurrent and enduring short-term changes in behavior and daily life experiences drive long-term changes in personality traits. These theories also propose transactional processes: Personality traits evoke a characteristic pattern of behavior that increases the probability of exposure to specific environments and life experiences (i.e., selection effects). Similarly, environmental factors act on personality traits through situational processes—through the filter of individual experiences (i.e., socialization effects).

The recently developed TESSERA framework on personality development in adulthood postulates that short-term personality-changing processes can be generalized as “recursive sequences of triggering situations, expectancy, states/state expressions, and reactions” (TESSERA; Wrzus & Roberts, 2017). Internal reflective or associative processes transform repeated TESSERA sequences into long-term personality development. Internal reflective processes may include self-reflection, accommodation, as-

simulation, life reflection, and self-narration. Internal associative processes may include implicit learning, reinforcement learning, or habit formation. The authors of the TESSERA framework explain age differences in personality development through variations in components and processes that occur due to physical, cognitive, social, and societal changes related to age.

## Participation in Leisure Activities: A Driver of Personality Development?

Based on the aforementioned theories, personality change may be triggered through bottom-up processes that are part of a person's daily leisure activities and experiences. In addition, an individual's personality traits will impact the selection of situations, i.e., the type and frequency of leisure activities (Wrzus & Roberts, 2017).

According to the TESSERA framework, personality traits may change if the following short-term process is repeated: A certain leisure activity such as political engagement (a triggering situation) is perceived to be relevant to a trait such as extraversion (expectancy) and thus elicits a relevant state such as speaking in front of a crowd (states/state expression). This state level does not correspond to the actual trait level, e.g., low extraversion, and the reaction elicited is positive: The political talk is a success, and people are convinced (reaction). In the long run, reflective processes such as self-narration or associative processes such as habit formation may lead to higher extraversion in this example (Wrzus & Roberts, 2017). According to this theory, being active and involved in leisure activities may increase the number of potentially triggering situations and thus increase the probability of personality trait change.

## What Personality-Leisure Activity Transactions Can We Expect?

Many leisure activities have a social component (Karp et al., 2006). The majority of research investigating the role of social engagement in personality development has focused on social network size (e.g., Lang et al., 1998; Mund et al., 2018) or social role status (e.g., Lodi-Smith & Roberts, 2012) but less on leisure behavior. Up to now, research on the relationship between personality and leisure activity has been rare. In line with Stephan, Boiché, et al. (2014), in the following we review earlier studies on this topic, broadly ordered by physical, social, and cognitive leisure activities. Some leisure activities may involve more than one of these domains: We summarize the evidence on this in the section “Other activities”.

## Overall Participation in Leisure Activities

In a study on two adult lifespan samples from different western societies, Stephan, Boiché, et al. (2014) showed that individuals who scored higher on extraversion and openness were more likely to engage in a variety of types of leisure activities.

High extraversion has predicted not only a greater variety of leisure activities but also a higher frequency of overall participation in leisure activities (Brandstätter, 1994; Kirkcaldy & Furnham, 1991; Lu & Hu, 2005; Speaks, 2013; Wag-

ner et al., 2016). This may be due to higher sensation-seeking (Furnham, 2004) and to the social component of most leisure activities, which may attract extraverted people (Stephan, Boiché, et al., 2014).

In contrast, high neuroticism has been shown to predict low participation in leisure activities (Kirkcaldy & Furnham, 1991; Speaks, 2013). However, there is also some evidence that neuroticism is not associated with recreational interest (Nias, 1985) or that it is only associated on a facet level (Barnett, 2013). Barnett (2013) found that low depression and high impulsivity were positively associated with the desire to seek intrinsic rewards through leisure activities.

In addition, people scoring higher on extraversion and openness to experience are more likely to search for new experiences, challenges, and skills; intrinsic rewards (laughing/having fun); social interactions; and active engagement in their free time compared to people scoring low on these traits. The search for challenges and interest in developing skills has also been predicted by higher conscientiousness (Barnett, 2013). People high in agreeableness, in contrast, have been shown to pursue leisure activities with the aims of relieving stress and feeling good (Barnett, 2013).

### **Physical Activities**

Cross-sectional research has found that physical activity is mainly positively correlated with extraversion (Egloff & Gruhn, 1996; Kirkcaldy & Furnham, 1991; Rhodes & Smith, 2006; Sale et al., 2000) and negatively correlated with neuroticism (Barnett, 2006; Rhodes & Smith, 2006; Speaks, 2013). There have been mixed results on the relationship between the level of involvement in leisure sports and conscientiousness (Barnett, 2006; Jopp & Hertzog, 2010; Rhodes & Smith, 2006), agreeableness (Jopp & Hertzog, 2010; Rhodes & Smith, 2006; Speaks, 2013), and openness to experience (Rhodes & Smith, 2006).

Longitudinal research has shown that personality and physical activity are interlinked. In one longitudinal study, more physically active individuals experienced lower declines in conscientiousness, extraversion, openness, and agreeableness over time (Stephan, Sutin, et al., 2014). Another longitudinal study testing bidirectional associations revealed that increasing conscientiousness and openness predicted subsequent increases in physical activity, whereas increasing agreeableness predicted subsequent decreases in physical activity (Allen et al., 2017). Allen et al. (2017) concluded that personality is important for changes in physical activity, but physical activity has virtually no effect on changes in personality.

### **Social Activities**

In past research, social leisure activities were predominantly correlated with extraversion (Stephan, Boiché, et al., 2014). Using time-sampling diaries, Brandstätter (1994) found that extraverts preferred high-stimulation social situations. Social leisure activities can be subdivided into “private” and “public” socializing (Jopp & Hertzog, 2010).

Private socializing, which includes getting together with friends, relatives, and acquaintances, appears to be associated with higher extraversion (Jopp & Hertzog, 2010; Nias,

1985; Speaks, 2013). Also, high agreeableness was predictive of the desire for social interactions (Barnett, 2013) and actual socializing (Speaks, 2013) in leisure time.

Public socializing may include engagement in political activities, giving public talks, volunteering, and attending club meetings. Similar to private socializing, public socializing appears to be positively associated with both agreeableness (Barnett, 2013; Carlo et al., 2005; Jopp & Hertzog, 2010; Penner, 2002; Speaks, 2013) and extraversion (Carlo et al., 2005; Penner, 2002; Speaks, 2013). Some cross-sectional studies have suggested a positive association between community involvement and conscientiousness (Lodi-Smith & Roberts, 2007; Speaks, 2013); others have not (Carlo et al., 2005). Results are also mixed for openness (Carlo et al., 2005; Speaks, 2013). Previous research has shown no relationship between volunteering and neuroticism (Carlo et al., 2005; Lodi-Smith & Roberts, 2007).

### **Cognitive Leisure Activities**

Cognitive activities are often differentiated into developmental activities (e.g., reading, writing, going to movies, or attending public lectures) and gaming activities (e.g., doing crosswords or puzzles or playing Scrabble) (Jopp & Hertzog, 2007, 2010; Stephan, Boiché, et al., 2014). Most studies have shown positive correlations with the trait of openness to experience.

Research has produced partially contradictory findings on the connection between gaming and personality. In one study, gaming activities were found to be positively associated with openness to experience (Jopp & Hertzog, 2010), whereas other studies have found no significant effects on any personality trait (Stephan, Boiché, et al., 2014) and some have even found negative associations with extraversion and neuroticism (Kirkcaldy & Furnham, 1991). Engaging in developmental cognitive activities, such as reading, was consistently related to higher openness to experience (Jopp & Hertzog, 2010; Speaks, 2013; Stephan, Boiché, et al., 2014).

### **Other Activities**

Leisure activities such as artistic and musical activities, crafts, computer use, watching television, and travel do not fit clearly into the aforementioned physical, social, and cognitive domains. Nevertheless, previous studies have linked these activities as well to personality traits.

Artistic activities in areas such as cultural arts, arts and crafts, and dancing were positively correlated with openness to experience (Speaks, 2013). Similarly, increases in cultural activity such as going to the theater precipitated increases in openness and vice versa. These culture-openness transactions held across different age and education groups and when controlling for household income (Schwaba et al., 2018). Likewise, research has found that students who enjoy listening to music and attending concerts are high in openness to experience (Barnett, 2006). Further, technology use (i.e., using a computer) and playing an instrument were also positively correlated with openness, and watching television was negatively related to openness to experience (Jopp & Hertzog, 2010). Kirkcaldy & Furnham (1991) found that arts and handicrafts such as

painting, drama, and pottery were positively correlated with extraversion, but they did not examine openness.

To our knowledge, there is no research on the associations between personality traits and more modern leisure activities such as going out to restaurants, bars, and movies. These kinds of activities may combine cognitive, social, and physical activity components.

## Summary of Theory and Evidence

Past research has found mean-level change (e.g., Hopwood & Bleidorn, 2018), some rank-order instability (e.g., Damian et al., 2019), and individual differences (e.g., Schwaba & Bleidorn, 2018) in personality across the lifespan. Recurrent short-term changes in behavior and experiences in daily life may drive long-term changes in personality traits. In turn, personality traits may evoke a characteristic pattern of (leisure) behavior (e.g., Roberts, 2018; Wagner et al., 2020; Wrzus & Roberts, 2017).

The existing body of mainly cross-sectional studies suggests positive associations between participation in different leisure activities with extraversion and openness to experience. Additionally, in some studies, physical activities were associated with higher conscientiousness and lower agreeableness. Further, social activities were associated with higher agreeableness and cognitive activities with higher openness.

However, a systematic understanding of whether and how participation in leisure activities contributes to personality change and vice versa is still lacking. To come closer to identifying the underlying mechanisms of personality change, we must investigate how changes in individuals' behavior and experiences (e.g., leisure activities) affect their future personality. Comparing personality changes in people who are more active in their leisure time with those who are less active would not allow such causal conclusions. To gain valid insights about prospective effects between personality and leisure activities, we must distinguish between-person and within-person variance in longitudinal data.

## Current Study

The objective of this research was to examine whether leisure activities are drivers of personality development. More specifically, we aimed to examine the extent to which within-person changes in overall participation in leisure activities and participation in specific leisure activities lead to prospective changes in an individual's Big Five personality traits, and whether changes in personality elicit prospective changes in a person's leisure activities.

This study was based on longitudinal analyses using random-intercept cross-lagged panel models (Hamaker et al., 2015). The data came from a large and nationally representative household panel study from Germany, surveying more than 55,000 adults (SOEP). All Big Five personality traits (openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism) and the self-reported frequency of different leisure activities were assessed in 2005, 2009, 2013, and 2017.

First, we investigated the effect of changes in *overall participation in leisure activities* (sum score across all activities)

on personality development and vice versa. We hypothesized that there are positive within-person transactions between openness to experience and extraversion, on the one hand, and overall participation in leisure activities, on the other. This is an advance on past research, which investigated between-person effects only. Further, we investigated these transactions for six different specific leisure activities:

Second, we examined the transactions between *physical activities*, (i.e., playing sports) and personality development. In line with aforementioned research, we expected unidirectional positive cross-lagged effects of conscientiousness and openness, and negative cross-lagged effects of agreeableness on physical activities.

Third, we examined the transactions between *socializing* (e.g., meeting friends, relatives, acquaintances, or neighbors) and personality development. The evidence from cross-sectional data presented above suggests that an increased frequency of private socializing may result in increasing extraversion and agreeableness and vice versa.

Fourth, we examined the transactions between *volunteering* (e.g., volunteer work in clubs, associations, or community organizations) and personality development. Increases in volunteering may trigger increases in the traits of extraversion and agreeableness and vice versa.

Fifth, we examined the transactions between *political activities* (e.g., participation in citizens' initiatives, political parties, and local politics) and personality development. Increases in political activities may trigger an increase in the traits of extraversion and agreeableness and vice versa.

Sixth, we investigated the transactions between *artistic and musical activities* (e.g., making music, dancing, doing theater, painting, photography) and personality development. Considering earlier research, we expected that increases in the frequency of artistic and musical activities may trigger increases in openness and vice versa.

Seventh, we investigated the transactions between activities such as going to movies, restaurants, concerts, dancing, and attending sporting events, to which we refer as *going-out activities*, and personality development. Considering earlier research, we expected that an increased frequency of going-out activities may trigger an increase in extraversion and openness to experience and vice versa.

Using a random-intercept cross-lagged panel model (RI-CLPM), we disentangled between-person and within-person effects to reveal the within-person longitudinal relationship between participation in leisure activities and personality development. The outcomes of this study provide evidence that can be used to evaluate recently proposed models of personality stability and change.

## Method

### Participants and Procedure

The data used in this study came from the German Socio-Economic Panel Study (SOEP; data from 1984–2017; Version 34, 2019), based at the German Institute for Economic Research (DIW Berlin). The SOEP started in 1984 and is a large, ongoing survey of private households in Germany, and includes all household members. Households were initially chosen using a multistage random sampling tech-

nique with regional clustering. Refresher samples have been added periodically to maintain the representativeness of the data and to increase the sample size. Further, new household members (e.g., adult children or new partners) are regularly invited to join the study and are interviewed annually as well. Individuals are followed even in cases of relocation or a split of a household. For detailed information about the participants, design, subsamples, variables, and assessment procedures, see Goebel et al. (2018). We have included every subsample and refresher sample (A-M) in the SOEP. Attrition in the SOEP was below 5% yearly across various subsamples for waves 1984 to 2016 (Kroh et al., 2018). We included all individuals who were born between 1930 and 1987, i.e., who were between 18 and 75 years of age at T1 in 2005. The maximum number of observations used was  $N = 43,651$ .

## Age Groups

For additional analysis, we generated age groups of approximately equal size: Group 1, *young adults* ( $M = 24.1$ ,  $\min = 18$ ,  $\max = 30$  years old at T1, i.e. in 2005; born 1975–1987;  $N = 17,151$ ); Group 2, *middle-aged adults* ( $M = 39.6$ ,  $\min = 31$ ,  $\max = 50$  years old at T1; born 1955–1974;  $N = 24,546$ ), and Group 3, *older adults* ( $M = 61.3$ ,  $\min = 51$ ,  $\max = 75$  years old at T1; born 1930–1954;  $N = 14,093$ ). For descriptive statistics based on these age groups, in 2005, please see Supplement S1.

## Measures

### Big Five

The Big Five personality traits were measured four times, first in 2005 and then again in 2009, 2013, and 2017, using the BFI-S (Gerlitz & Schupp, 2005; Hahn et al., 2012), which is a short version of the BFI (John et al., 1991; see also John et al., 2008, and Lang et al., 2001, for further information on the scale, the German translation, and evidence on its reliability and validity). The BFI-S contains 15 items, and participants were asked to indicate their agreement on a scale ranging from 1 (does not describe me at all) to 7 (describes me perfectly).

### Leisure Activities

Leisure activities were measured by asking participants how often respondents spend time on a range of specific leisure activities. These were assessed in 2005, 2009, 2013, and 2017. Participants were asked to answer the question: “Which of the following activities do you take part in during your free time? Please check off how often you do each

activity: at least once a week (1), at least once a month (2), less often (3), never (4).<sup>1</sup> Items were reverse-coded so that higher values express a greater frequency. We used six items<sup>2</sup>: “Doing sports yourself”, “Meeting with friends, relatives, or neighbors”, “Volunteer work in clubs or social services”, “Involvement in a citizens’ group, political party, local government”, “Artistic and musical activities (playing music, singing, dancing, acting, painting, photography)”, and “Going to the movies, pop music concerts, dancing, disco, sports events”.<sup>3</sup> To measure the level of overall participation, we summed up the frequency scores of all six leisure activities to obtain an index with higher scores indicating higher overall participation in leisure activities (see Gerstorf et al., 2016).

## Statistical Model

To examine the interdependency between the Big Five personality traits and different leisure activities, we estimated a random-intercept cross-lagged panel model (RI-CLPM), which was first proposed by Hamaker et al. (2015). Our model is depicted in Figure 1.

For analysis, we used the package lavaan (Rosseel, 2012) in the open-source software R, version 4.0.2. Missing data were handled using full information maximum likelihood estimation. For model estimation, we standardized personality and leisure activity scores to a mean of zero and a standard deviation of one across all waves.

### RI-CLPM: Distinguishing Between-Person From Within-Person Effects

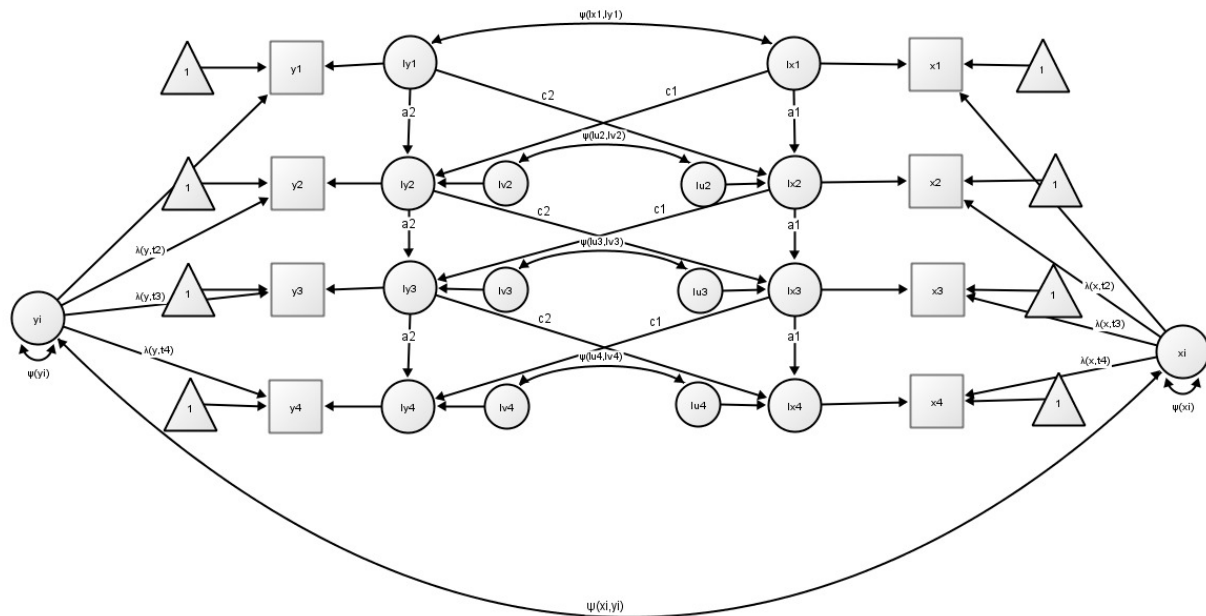
The RI-CLPM model offers some advantages over the traditional cross-lagged panel model (Finkel, 1995; see also Mund & Nestler, 2019, or Orth et al., 2020, for more statistical reasoning and model comparison). Most importantly, the model allows us to distinguish between within-person and between-person effects (Allison, 2009). This distinction is achieved by allowing individuals to vary around their own trait-like mean over time instead of fluctuating around a common group mean (Mund & Nestler, 2019). Thus, we control for stable differences between individuals (also called unit effects). Between-person effects are modeled by adding a latent (random) intercept ( $\xi_i$ ,  $\eta_i$ ) for each of the respective constructs. To hold the random intercepts constant, it is important to also estimate their variance ( $\psi(x_i)$ ,  $\psi(y_i)$ ) and covariance ( $\psi(x_i, y_i)$ ) (Hamaker et al., 2015). This covariance then reflects how stable between-person differences in one construct are in relation to between-person differences in the other construct. Thus, the RI-CLPM controls for stable differences due, for example, to gender or other relatively stable characteristics that make individ-

1 In 2013 answering format differed from 2005, 2009 and 2017: 1 = daily, 2 = every week, 3 = at least once a month, 4 = seldom, 5 = never; for better comparability to other waves, we collapsed “daily” and “every week” to “at least once a week”.

2 We had to exclude the item “Going to cultural events such as concerts, theater, lectures, etc.”, due to differing included activities in 2013 and therefore significant mean difference compared to 2005, 2009 and 2017.

3 In wave 2013, “sporting events” was a separate item; for better comparability to other waves we collapsed this into our category “going-out activities”.





**Figure 1. Random-intercept cross-lagged panel model (RI-CLPM) used in this study.**

$x_i, y_i$  = random intercepts;  $\lambda_{xt}, \lambda_{yt}$  = time-varying factor loadings;  $\psi(x_i), \psi(y_i)$  = variance of the random intercepts;  $\psi(x_i, y_i)$  = covariance of the random intercepts;  $x, y$  = variables;  $ly, lx$  = phantom latent variables;  $\psi(lvi, lui)$  = covariance of the phantom variables;  $a_1, a_2$  = autoregressive paths;  $c_1, c_2$  = cross-lagged paths

uals systematically different over time. Estimated auto-regressive (AR) and cross-lagged (CL) terms are therefore no longer confounded by stable between-person differences.

We slightly adjusted the way the random intercept is implemented compared to the originally proposed model. Hamaker et al. (2015) expected the unit effects to be stable differences over time, expressed by fixed factor loadings ( $\lambda = 1$ ). Since we analyzed a prolonged time frame, we assume that unit effects characteristics, or how they are expressed, do in fact change over time (Zyphur et al., 2020). We therefore decided to include time-varying factor loadings ( $\lambda_{xt}, \lambda_{yt}$ ) to allow unit effects to affect the observed variables differently on each occasion of measurement.<sup>4</sup> This improved the model fit significantly. Consequently, the random intercept factor captures possible confounders, thus, potentially changing between-person differences such as household income.

In addition, our model includes a mean structure with observed variable intercepts to account for epoch effects, i.e., overall changes in the sample across occasions (Zyphur et al., 2020).

### Interpretation of RI-CLPM

Within-person AR ( $a_1, a_2$ ) and CL ( $c_1, c_2$ ) terms in the RI-CLPM properly reflect how a deviation from the individ-

ual's own mean in one variable is predicted by a random, unpredicted change on the previous occasion. To be more precise, the estimated AR terms in the RI-CLPM reflect how much of a deviation from the individual's mean in a leisure activity ( $a_1$ ) or personality trait ( $a_2$ ) on one occasion persists on the next occasion.

The  $c_1$  terms represent the estimated change in the individual's personality trait due to an unexpected change in an individual's leisure activity on the previous occasion. The  $c_2$  terms represent the estimated change in the individual's leisure activity due to an unexpected change in a personality trait on the previous occasion. Unexpected change in this instance means that this change was not predicted by the underlying statistical model and thus occurs as a shock or disturbance to the system. However, it is important to note that in the RI-CLPM, cross-lagged effects capture only temporary effects of one construct on the other. In this paper, we refer to these as "short-term boosts" even though they occur at four-year intervals. The RI-CLPM cannot detect sustained prospective effects over multiple time points, which can be seen as a flaw of this model (see Orth et al., 2020).

The covariance of the phantom variables at each measurement occasion ( $\psi(lvi, lui)$ ) shows whether temporary deviations from a person's leisure activities score are associated with simultaneous temporary deviations from their

<sup>4</sup> The comparison of time-invariant and time-varying unit effect models showed that the within-person cross-lagged terms and correlated change effects generally do not differ. The within-person auto-regressive terms are slightly larger in the more restricted models. But there was no relevant difference in the significance of the parameters. For full results on restricted versus unrestricted factor loadings of unit effects, please see R scripts and outputs on OSF: [https://osf.io/fdxzp/?view\\_only=eaffa966ffe14e7c8a4ccb5ace76ace6](https://osf.io/fdxzp/?view_only=eaffa966ffe14e7c8a4ccb5ace76ace6).

personality trait score. We call this covariance “within-person correlated change effects” in the following.

### Granger-Sims Causality Tests

For hypothesis testing, we used Granger-Sims causality tests (Granger, 1969; Sims, 1980) as proposed by Zyphur et al. (2020). For these, we first fitted our full RI-CLPM and then restricted different paths to zero while comparing model fit. Whenever the more restricted model fits were worse than the full model, this implied that the restricted paths significantly improve the model when freely estimated (Mulder & Hamaker, 2020). In addition, Granger-Sims causality tests allow us to test for feedback effects (i.e., bidirectional causality) by restricting both CL paths to zero and then comparing model fit to the full model (Zyphur et al., 2020).

### Moderation Effects of Age Groups in RI-CLPM

Subsequently we expanded the RI-CPLM by adding the categorical age grouping variable to the model. Age group differences were investigated by comparing a multiple group version of the RI-CLPM in which there are no constraints across the age groups with a model in which the lagged regression coefficients are constrained to be identical across the groups (see Mulder & Hamaker, 2020). We therefore know from chi-square difference tests whether there is a moderation effect of age group or not. To keep the number of models at a presentable and parsimonious level, we decided to test only whether the full model would show differences between the age groups and present the results in the supplemental materials S1 and S3-S9 only. To facilitate replicability, we provide the complete syntax on

<https://osf.io/>

[fdxzp/view\\_only=eaffa966ffe14e7c8a4ccb5ace76ace6](fdxzp/view_only=eaffa966ffe14e7c8a4ccb5ace76ace6)

## Results

We present means, standard deviations, minimums, and maximums of all study variables across waves in Table 1 and by age groups in Supplement 1 (S1). Zero-order stabilities of leisure activities, that is, the correlation of one measurement occasion with the following, vary around  $r = .50$ , ranging between  $r = .42$  for socializing across waves and  $r = .60$  for physical activity across waves. For comparison: The zero-order stability of the Big Five personality traits ranges between  $r = .53$  and  $r = .69$ . The strongest correlation between leisure activities was observed between physical activities and going-out activities ( $r = .40$  at  $t1$ ). The weakest association was found for political activities and socializing ( $r = 0.03$  at  $t1$ ). Intercorrelations among all leisure activities and Big Five personality traits over four waves can be found in the supplemental materials (S2). Of the Big Five trait domains, openness had the strongest concurrent associations with overall participation in leisure activities ( $rs$  of  $.22 - .28$ ).

### Attrition Analyses

In total, we used data from 55,790 individuals, 6,236 of whom (11.2%) provided data for all four waves between 2005 and 2017 ( $N_{2005} = 18,849$ ;  $N_{2009} = 18,035$ ;  $N_{2013} =$

16,242;  $N_{2017} = 21,767$ ). Mean-level comparisons indicated that the participants who completed all four waves were, on average, older in 2005 ( $M = 46.98$  vs.  $M = 39.05$ ,  $t(55,789) = -37.86$ ,  $p < .001$ ,  $d = 0.52$ ), but were not different from non-completers with respect to gender ( $\chi(1) = 1.075$ ,  $p = .30$ ). There were small but nevertheless significant differences between these two groups in personality traits in 2005: openness ( $M_{\text{completers}} = 4.49$  vs.  $M_{\text{non-completers}} = 4.57$ ;  $t(19194) = -4.38$ ,  $p = 0.000$ ,  $d = -.068$ ), extraversion ( $M_{\text{completers}} = 4.84$  vs.  $M_{\text{non-completers}} = 4.84$ ;  $t(19302) = -0.33$ ,  $p = 0.37$ ,  $d = -.005$ ), agreeableness ( $M = 5.43$  completers vs.  $M_{\text{non-completers}} = 5.44$ ;  $t(19288) = -0.61$ ,  $p = 0.27$ ,  $d = -.009$ ), conscientiousness ( $M_{\text{completers}} = 5.90$  vs.  $M = 5.95$ ;  $t(19231) = -3.12$ ,  $p < 0.001$ ,  $d = -.048$ ), neuroticism ( $M_{\text{completers}} = 3.98$  vs.  $M_{\text{non-completers}} = 3.94$ ;  $t(19282) = 2.07$ ,  $p = 0.02$ ,  $d = .032$ ). Overall participation in leisure activities was slightly higher in participants who completed all four waves ( $M_{\text{completers}} = 51.24$  vs.  $M_{\text{non-completers}} = 49.98$ ;  $t(19093) = -8.34$ ,  $p = 0.000$ ,  $d = -.128$ ) compared to non-completers.

### Random-Intercept Cross-Lagged Panel Models

We tested the relations between leisure activities and Big Five personality traits based on RI-CLPMs, each in a separate model. Figure 1 provides a generic illustration of the bivariate RI-CLPMs. RI-CLPM explicitly models the stable between-person variance for each construct. Consequently, a within-person cross-lagged effect tests for the prospective effect of a random deviation from an individual's mean level of one construct at an early occasion on the deviation from the usual level of the other construct at a later occasion.

### Overall Participation in Leisure Activities

Table 2 shows the standardized estimates, standard errors, and exact  $p$  values of the covariation of random intercepts and the within-person AR and CL paths. Further, model fit statistics and results of Granger-Sims causality tests are reported for the overall participation in leisure activities and all Big Five personality traits separately.

At the between-person level, individuals with a higher overall participation in leisure activities are considerably more open ( $\psi = .251$ ,  $p < .001$ ) and more extraverted ( $\psi = .132$ ,  $p < .001$ ), and less conscientious ( $\psi = -.032$ ,  $p < .001$ ) and less neurotic ( $\psi = -.120$ ,  $p < .001$ ) than individuals with lower overall participation. No significant covariance between the random intercept of overall participation and agreeableness was found.

At the within-person level, temporary deviations from a person's overall participation score are positively associated with simultaneous temporary deviations from their openness ( $rs$  of  $.029 - .054$ ,  $p < .001$ ) and extraversion trait scores ( $rs$  of  $.020 - .054$ ,  $p < .001$ ). Temporary deviations from a person's overall participation score were negatively associated with simultaneous temporary deviations from their neuroticism trait score at first and last measurement occasions only ( $rs$  of  $-.039 - -.018$ ,  $p < .001$ ). There were no simultaneous temporary deviations of overall participation in leisure activities with conscientiousness and agreeableness trait scores.



**Table 1. Descriptive Statistics of Leisure Activities and Personality**

	2005					2009					2013					2017				
	N	Min	Max	M	SD	N	Min	Max	M	SD	N	Min	Max	M	SD	N	Min	Max	M	SD
Age	55790	18	75	40.34	14.88	55790	22	79	44.34	14.88	55790	26	83	48.34	14.88	55790	30	87	52.34	14.88
Big 5 Traits																				
Openness	19196	1	7	4.52	1.20	18380	1	7	4.64	1.10	16618	1	7	4.81	1.06	23662	1	7	4.95	1.09
Conscientiousness	19233	1	7	5.92	0.92	18437	1	7	5.86	0.92	16697	1	7	5.89	.89	23868	1	7	5.87	.91
Extraversion	19304	1	7	4.84	1.13	18459	1	7	4.77	1.14	16735	1	7	4.84	1.11	23901	1	7	4.94	1.13
Agreeableness	19290	1	7	5.44	.98	18481	1	7	5.33	.98	16733	1	7	5.40	.96	23937	1.33	7	5.48	.99
Neuroticism	19284	1	7	3.96	1.22	18502	1	7	3.83	1.22	16733	1	7	3.76	1.22	23965	1	7	3.76	1.24
Leisure Activities																				
Overall Participation	19095	6	24	12.11	3.22	18308	6	24	12.06	3.20	22422	6	24	12.60	3.31	22030	6	24	12.22	3.24
Physical A.	19346	1	4	2.37	1.29	18594	1	4	2.43	1.32	22677	1	4	2.64	1.36	22167	1	4	2.52	1.37
Socializing	19389	1	4	3.21	.81	18592	1	4	3.16	0.80	22695	1	4	3.11	.86	22202	1	4	3.15	.82
Volunteering	19360	1	4	1.61	.99	18556	1	4	1.60	1.02	22663	1	4	1.65	1.06	22156	1	4	1.67	1.06
Political A.	19335	1	4	1.15	.49	18539	1	4	1.12	.45	22647	1	4	1.16	.50	22139	1	4	1.13	.47
Artistic & Musical A.	19302	1	4	1.74	.96	18522	1	4	1.76	.96	22696	1	4	1.96	1.11	22158	1	4	1.79	1.05
Going-Out A.	19377	1	4	2.05	.85	18603	1	4	1.96	.79	22651	1	4	2.08	.86	22196	1	4	1.96	.76

**Table 2. Overall Participation (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43543			N = 43619			N = 43592			N = 43639			N = 43651		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	0.193	0.012	0.000***	0.193	0.012	0.000***	0.194	0.012	0.000***	0.192	0.012	0.000***	0.193	0.012	0.000***
a2 (P)	0.122	0.011	0.000***	0.134	0.012	0.000***	0.114	0.011	0.000***	0.109	0.011	0.000***	0.122	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	0.005	0.010	0.575	0.004	0.010	0.703	0.024	0.009	0.010*	-0.008	0.010	0.431	-0.005	0.010	0.629
c2 (P → LA)	0.004	0.008	0.604	0.000	0.008	0.970	0.014	0.008	0.097	0.007	0.007	0.338	-0.006	0.008	0.411
Covariances															
Random intercepts $\psi(X_i, Y_i)$	0.251	0.006	0.000***	-0.032	0.006	0.000***	0.132	0.006	0.000***	0.008	0.006	0.168	-0.120	0.006	0.000***
Corr. change $\psi(l_{v_1}, l_{u_1})$	0.054	0.006	0.000***	-0.011	0.006	0.061	0.054	0.006	0.000***	-0.008	0.006	0.171	-0.039	0.006	0.000***
Corr. change $\psi(l_{v_2}, l_{u_2})$	0.032	0.005	0.000***	0.009	0.005	0.099	0.029	0.005	0.000***	0.007	0.005	0.189	-0.001	0.005	0.881
Corr. change $\psi(l_{v_3}, l_{u_3})$	0.029	0.005	0.000***	-0.008	0.006	0.130	0.024	0.005	0.000***	-0.003	0.006	0.556	-0.007	0.005	0.167
Corr. change $\psi(l_{v_4}, l_{u_4})$	0.038	0.005	0.000***	0.013	0.005	0.008	0.020	0.005	0.000***	0.007	0.005	0.190	-0.018	0.005	0.000***
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	52.323	(11)		71.139	(11)		71.086	(11)		43.128	(11)		41.005	(11)	
CFI / TLI	0.999	0.998		0.999	0.996		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.008		0.011	0.010		0.011	0.009		0.008	0.007		0.008	0.006	
AIC / BIC	403018	403304		413371	413657		404935	405222		414354	414640		409439	409725	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	52.638	(12)		71.285	(12)		77.712	(12)		43.748	(12)		41.239	(12)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.008		0.011	0.010		0.011	0.009		0.008	0.007		0.008	0.006	
AIC / BIC	403016	403294		413368	413646		404941	405218		414353	414631		409437	409715	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.314	(1)	0.575	0.146	(1)	0.703	6.626	(1)	0.010*	0.620	(1)	0.431	0.233	(1)	0.629
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	52.592	(12)		71.141	(12)		73.839	(12)		44.048	(12)		41.681	(12)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.008		0.011	0.010		0.011	0.009		0.008	0.007		0.008	0.006	
AIC / BIC	403016	403294		413368	413646		404937	405215		414353	414631		409437	409715	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.269	(1)	0.604	0.001	(1)	0.970	2.753	(1)	0.097	0.921	(1)	0.337	0.676	(1)	0.411

Step 4: Constrain all cross-lagged terms															
χ² (df)	52.721	(13)		71.353	(13)		77.973	(13)		46.102	(13)		41.691	(13)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.008	0.008		0.011	0.010		0.011	0.009		0.008	0.007		0.008	0.006	
AIC / BIC	403014	403283		413366	413635		404939	405208		414353	414622		409435	409704	
χ² Difference Test (diff <sub>df</sub> ) p	0.398	(2)	0.820	0.214	(2)	0.899	<b>6.887</b>	(2)	0.032*	2.974	(2)	0.226	0.452	(2)	0.501

Note. P = personality; LA = leisure activity; SE = standard errors; Corr. change = within-person correlated change; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

AR terms at the within-person level show higher stability for the overall volume of participation in leisure activities ( $\beta$ s of .192–.194) compared to personality traits ( $\beta$ s of .109–.134). This means that the persistence of a random deviation from an individual's mean from one occasion to the next is greater for overall participation than for personality traits.

An examination of CL paths shows that there are longitudinal within-person associations for overall participation and extraversion but not for other personality traits. Granger-Sims causality tests revealed that the model fit significantly deteriorates when constraining the cross-lagged path (c1) to extraversion ( $\Delta\chi^2(1) = 6.626, p < .05$ ), implying an overall participation  $\rightarrow$  extraversion prospective effect ( $\beta = .024, p < .05$ ). That is, a positive within-person deviation from a person's usual overall participation level leads to a prospective positive within-person deviation from the person's trait level in extraversion. Further, constraining all cross-lagged paths and comparing model fit to the full model ( $\Delta\chi^2(2) = 6.887, p < .05$ ) revealed feedback effects of extraversion and overall participation. This means that a short-term boost in extraversion or overall participation may impact extraversion or overall participation, or both, through reciprocal effects.

Adding an age group variable to the model reveals that, at the within-person level, the CL path from overall participation to extraversion is significant for young adults (18–30 years) and older adults (51–75 years), but not for middle-aged adults (31–50 years). In contrast, for middle-aged adults, a prospective within-person effect is only significant in the opposite direction, from extraversion to overall participation. At the between-person level, adding an age group variable reveals a significant positive covariance of overall participation in leisure activities and agreeableness. That is, people with higher levels of overall leisure activities are more agreeable than people who are less active (see Supplement S3 for details).

### Physical Activities

Standardized estimates, standard errors, and exact  $p$ -values of the RI-CLPM and Granger-Sims causality tests for physical activity and personality traits are presented in Table 3.

At the between-person level, individuals with higher physical activity in their leisure time are more open ( $\psi = .146, p < .001$ ) and more extraverted ( $\psi = .068, p < .001$ ), slightly less agreeable ( $\psi = -.011, p < .05$ ) and less neurotic ( $\psi = -.082, p < .001$ ) than individuals with a lower level of physical activity. No significant covariance between the random intercept of physical activity and conscientiousness was found.

At the within-person level, temporary deviations from a person's physical activity score are positively associated with simultaneous temporary deviations from their openness ( $rs$  of .029 and .018,  $p < .01$ ), conscientiousness ( $rs$  of .013 and .014,  $p < .05$ ), and extraversion ( $rs$  of .025 and .014,  $p < .001$ ) trait scores at two measurement occasions. Temporary deviations from a person's physical activity score were negatively associated with simultaneous temporary deviations

from their neuroticism trait at the first and last measurement occasion only ( $rs$  of -.023 and -.016,  $p < .001$ ). There were no simultaneous temporary deviations of physical activity and agreeableness trait scores.

AR terms at within-person level show higher stability for physical activity ( $\beta$ s of .152–.155) compared to personality traits ( $\beta$ s of .110–.134). That is, the persistence of a random deviation from the individual's average physical activity from one occasion to the next is greater for physical activity than for personality traits.

CL paths show that there are within-person longitudinal associations for physical activity and agreeableness, but not for other personality traits. Granger-Sims causality tests reveal that the model fit significantly deteriorates when constraining the cross-lagged path (c2) from agreeableness to physical activity ( $\Delta\chi^2(1) = 8.778, p < .01$ ), implying an agreeableness  $\rightarrow$  physical activity prospective effect ( $\beta = .025, p < .01$ ). Further, constraining all cross-lagged paths and comparing model fit to the full model ( $\Delta\chi^2(2) = 8.969, p < .05$ ) revealed feedback effects of agreeableness and physical activity. This means that a short-term boost in an individual's agreeableness or physical activity may impact one or both characteristics by way of reciprocal effects.

However, adding an age group variable shows that the within-person agreeableness  $\rightarrow$  physical activity prospective effect is significant in the middle age group (31–50 years) only (see Supplement S4 for details).

### Socializing

Results of the RI-CLPM and Granger-Sims Causality Tests for the association between private social activities, such as meeting family or friends, and personality traits are presented in Table 4.

At the between-person level, individuals with higher private social activity in their leisure time are more open ( $\psi = .098, p < .001$ ), more extraverted ( $\psi = .140, p < .001$ ), and more agreeable ( $\psi = .042, p < .001$ ), but slightly less conscientious ( $\psi = -.015, p < .05$ ) and less neurotic ( $\psi = -.071, p < .001$ ) than individuals who socialize less.

At the within-person level, temporary deviations from a person's socializing score are positively associated with simultaneous temporary deviations from their openness ( $rs$  of .015–.036,  $p < .05$ ), extraversion ( $rs$  of .044–.052,  $p < .01$ ), and agreeableness ( $rs$  of .016–.022,  $p < .05$ ) trait scores, at least at three of four measurement occasions. Temporary deviations from a person's socializing score were negatively associated with simultaneous temporary deviations from their neuroticism trait at three measurement occasions ( $rs$  of -.035, -.023 and -.016,  $p < .001$ ). For simultaneous temporary deviations of socializing and conscientiousness trait scores, there were associations in both directions at different measurement occasions ( $rs$  of -.014, .017, and .034,  $p < .05$ ).

At the within-person level, AR terms show lower stability for socializing ( $\beta$ s of .070–.075) compared to personality traits ( $\beta$ s of .109–.134). This means that the persistence of a random deviation from the individual's average social activity from one occasion to the next is smaller for socializing than for personality traits.

**Table 3. Physical Activities (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43563			N = 43644			N = 43609			N = 43657			N = 43667		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	0.152	0.011	0.000***	0.153	0.011	0.000***	0.155	0.011	0.000***	0.153	0.011	0.000***	0.154	0.011	0.000***
a2 (P)	0.121	0.011	0.000***	0.134	0.012	0.000***	0.116	0.011	0.000***	0.110	0.011	0.000***	0.121	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	-0.001	0.008	0.852	0.009	0.009	0.320	0.008	0.008	0.279	0.009	0.009	0.311	0.000	0.008	0.989
c2 (P → LA)	-0.006	0.009	0.533	0.009	0.009	0.315	-0.003	0.010	0.785	0.025	0.008	0.003**	-0.009	0.009	0.322
Covariances															
Random intercepts $\psi(\xi_i, \eta_i)$	0.146	0.006	0.000***	-0.011	0.006	0.055	0.068	0.005	0.000***	-0.011	0.006	0.045*	-0.082	0.006	0.000***
Corr. change $\psi(l\nu_1, l\nu_1)$	0.029	0.006	0.000***	-0.002	0.006	0.745	0.025	0.006	0.000***	0.001	0.006	0.832	-0.023	0.006	0.000***
Corr. change $\psi(l\nu_2, l\nu_2)$	0.013	0.006	0.022	0.013	0.006	0.024*	0.014	0.005	0.009**	0.009	0.006	0.127	0.001	0.006	0.859
Corr. change $\psi(l\nu_3, l\nu_3)$	0.013	0.006	0.025	0.001	0.006	0.871	0.006	0.006	0.275	0.008	0.006	0.223	-0.007	0.006	0.255
Corr. change $\psi(l\nu_4, l\nu_4)$	0.018	0.005	0.001**	0.014	0.006	0.011*	0.002	0.005	0.691	0.006	0.006	0.249	-0.016	0.006	0.003**
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	46.763	(11)		53.933	(11)		66.981	(11)		26.807	(11)		41.850	(11)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.996		0.999	0.999		0.999	0.998	
RMSEA / SRMR	0.009	0.007		0.009	0.008		0.011	0.009		0.006	0.006		0.008	0.007	
AIC / BIC	418095	418381		425769	426055		418337	418624		426704	426991		422247	422533	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	46.798	(12)		54.923	(12)		68.151	(12)		27.832	(12)		41.850	(12)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.997		0.999	0.999		0.999	0.998	
RMSEA / SRMR	0.009	0.007		0.009	0.009		0.010	0.009		0.005	0.006		0.008	0.007	
AIC / BIC	418093	418371		425768	426046		418336	418614		426703	426981		422245	422523	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.0348	(1)	0.852	0.990	(1)	0.320	1.170	(1)	0.279	1.025	(1)	0.311	0.000	(1)	0.989
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	47.151	(12)		54.944	(12)		67.055	(12)		35.586	(12)		42.829	(12)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.007		0.009	0.009		0.010	0.009		0.007	0.007		0.008	0.007	
AIC / BIC	418093	418371		425768	426046		418335	418613		426711	426989		422246	422524	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.387	(1)	0.534	1.011	(1)	0.315	0.0745	(1)	0.785	8.778	(1)	0.003**	0.980	(1)	0.322



Step 4: Constrain all cross-lagged terms															
χ² (df)	47.165	(13)		55.283	(13)		68.938	(13)		35.776	(13)		43.098	(13)	
CFI / TLI	0.999	0.998		0.999	0.997		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.007		0.009	0.009		0.010	0.009		0.006	0.007		0.007	0.007	
AIC / BIC	418091	418360		425766	426036		418335	418604		426709	426978		422244	422513	
χ² Difference Test (diff <sub>df</sub> ) p	0.402	(2)	0.818	1.350	(2)	0.509	1.957	(2)	0.376	<b>8.969</b>	(2)	0.011*	1.248	(2)	0.536

Note. P = personality; LA = leisure activity; SE = standard errors; Corr. change = within-person correlated change; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; Associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

**Table 4. Socializing (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43566			N = 43644			N = 43612			N = 43661			N = 43670		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	<b>0.070</b>	0.010	0.000***	<b>0.075</b>	0.010	0.000***	<b>0.072</b>	0.010	0.000***	<b>0.073</b>	0.010	0.000***	<b>0.073</b>	0.010	0.000***
a2 (P)	<b>0.128</b>	0.011	0.000***	<b>0.134</b>	0.012	0.000***	<b>0.117</b>	0.011	0.000***	<b>0.109</b>	0.011	0.000***	<b>0.123</b>	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	-0.004	0.007	0.606	<b>0.015</b>	0.007	0.043*	<b>0.028</b>	0.007	0.000***	-0.003	0.007	0.731	0.005	0.007	0.519
c2 (P → LA)	0.015	0.010	0.127	-0.002	0.009	0.828	<b>0.053</b>	0.010	0.000***	0.004	0.009	0.650	<b>-0.025</b>	0.010	0.010*
Covariances															
Random intercepts $\psi(X_i, Y_i)$	<b>0.098</b>	0.006	0.000***	<b>-0.015</b>	0.006	0.010*	<b>0.140</b>	0.006	0.000***	<b>0.042</b>	0.006	0.000***	<b>-0.071</b>	0.006	0.000***
Corr. change $\psi(lv_1, lv_1)$	<b>0.021</b>	0.006	0.001**	<b>-0.014</b>	0.007	0.028*	<b>0.044</b>	0.006	0.000***	-0.000	0.006	0.955	<b>-0.035</b>	0.006	0.000***
Corr. change $\psi(lv_2, lv_2)$	<b>0.015</b>	0.006	0.014*	<b>0.017</b>	0.006	0.007**	<b>0.045</b>	0.006	0.000***	<b>0.016</b>	0.006	0.014*	-0.012	0.006	0.052
Corr. change $\psi(lv_3, lv_3)$	<b>0.032</b>	0.006	0.000***	0.012	0.007	0.078	<b>0.052</b>	0.006	0.000***	<b>0.016</b>	0.007	0.018*	<b>-0.016</b>	0.006	0.012*
Corr. change $\psi(lv_4, lv_4)$	<b>0.036</b>	0.006	0.000***	<b>0.034</b>	0.006	0.000***	<b>0.046</b>	0.005	0.000***	<b>0.021</b>	0.006	0.001**	<b>-0.028</b>	0.006	0.000***
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	53.086	(11)		71.767	(11)		76.544	(11)		31.922	(11)		34.772	(11)	
CFI / TLI	0.999	0.996		0.997	0.994		0.998	0.995		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.009		0.011	0.011		0.012	0.011		0.007	0.006		0.007	0.007	
AIC / BIC	426261	426548		433321	433608		424239	424526		434131	434418		429820	430107	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	53.351	(12)		75.858	(12)		94.645	(12)		32.040	(12)		35.189	(12)	
CFI / TLI	0.999	0.997		0.997	0.994		0.998	0.994		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.009		0.011	0.011		0.013	0.012		0.006	0.006		0.007	0.007	
AIC / BIC	426260	426537		433323	433601		424256	424533		434129	434407		429819	430096	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.266	(1)	0.606	<b>4.090</b>	(1)	0.043*	<b>18.101</b>	(1)	0.000***	0.119	(1)	0.731	0.416	(1)	0.519
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	55.419	(12)		71.814	(12)		102.253	(12)		32.127	(12)		41.438	(12)	
CFI / TLI	0.999	0.997		0.998	0.994		0.997	0.994		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.009		0.011	0.011		0.013	0.013		0.006	0.006		0.007	0.007	
AIC / BIC	426262	426539		433319	433597		424263	424541		434130	434407		429825	430103	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	2.334	(1)	0.127	0.047	(1)	0.828	<b>25.709</b>	(1)	0.000***	0.205	(1)	0.651	<b>6.666</b>	(1)	0.010*

Step 4: Constrain all cross-lagged terms															
$\chi^2$ (df)	57.255	(13)		77.533	(13)		107.338	(13)		32.504	(13)		45.549	(13)	
CFI / TLI	0.999	0.997		0.997	0.994		0.997	0.994		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.009	0.010		0.011	0.011		0.013	0.013		0.006	0.006		0.008	0.008	
AIC / BIC	426261	426531		433323	433592		424266	424535		434128	434397		429827	430096	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	4.170	(2)	0.124	5.766	(2)	0.056	<b>30.794</b>	(2)	0.000 ***	0.583	(2)	0.747	<b>10.777</b>	(2)	0.005**

Note. P = personality; LA = leisure activity; SE = standard errors; Corr. change = within-person correlated change; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; Associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

CL results show that there are within-person longitudinal associations of social activity with conscientiousness, neuroticism, and extraversion. Granger-Sims causality tests revealed that the model fit significantly deteriorates when constraining the cross-lagged path (c1) from social activity to conscientiousness ( $\Delta\chi^2(1) = 4.090, p < .05$ ), implying a positive socializing  $\rightarrow$  conscientiousness prospective effect ( $\beta = .015, p < .05$ ), but no significant feedback effects were found here. There is also a significant negative within-person CL effect (c2) from neuroticism  $\rightarrow$  socializing ( $\Delta\chi^2(1) = 6.666, p < .05$ ;  $\beta = -.025, p < .05$ ). Additionally, we find feedback effects of neuroticism and socializing. This means that a short-term individual boost in neuroticism or social activity may impact one or both characteristics by way of reciprocal effects ( $\Delta\chi^2(1) = 10.777, p < .01$ ). Regarding extraversion and socializing, there are significant CL effects in both directions and feedback effects. Constraining CL (c1) revealed a socializing  $\rightarrow$  extraversion prospective effect ( $\Delta\chi^2(1) = 18.101, p < .001$ ;  $\beta = .028, p < .001$ ). That is, change in a person's extraversion may be due to an unexpected change in social activity on the previous occasion. The cross-lagged effect is even larger in the opposite direction (c2) from extraversion  $\rightarrow$  socializing ( $\Delta\chi^2(1) = 25.709, p < .001$ ;  $\beta = .053, p < .001$ ). Further, the test for feedback effects revealed a reciprocal within-person relationship between extraversion and private social activities ( $\Delta\chi^2(1) = 10.777, p < .01$ ).

Adding an age group variable to the model reveals that the within-person AR term for socializing is no longer significant in the oldest age group (51-75 years). This means that there is no persistence of a random deviation from the individual's average socializing on a previous occasion to the next occasion among older adults. However, there is a significant CL effect in the older age group from openness to socializing ( $\beta = .038, p < .01$ ), which was not found in the whole sample or the younger age groups. Another finding, after adding age groups, is that the within-person cross-lagged effect from extraversion  $\rightarrow$  socializing is smaller and not significant ( $\beta = .027, p = .160$ ) for young adults (18-30 years). Similarly, for neuroticism, the negative within-person CL effect (c2) on socializing is still significant ( $\beta = -.052, p < .001$ ) for the older age group (51-75 years) but not for young and middle-aged adults. The small between-person and within-person effects for socializing and conscientiousness do not hold when adding the age group variable. Please see Supplement S5 for details on results by age groups.

### Volunteering

Results of the RI-CLPM and Granger-Sims causality tests for the association between volunteer activities, such as volunteer work in clubs, associations, or community organizations and Big Five personality traits are presented in Table 5.

At the between-person level, individuals who volunteer

more often in their leisure time are more open ( $\psi = .082, p < .001$ ), more extraverted ( $\psi = .045, p < .001$ ), and less neurotic ( $\psi = -.057, p < .001$ ) than individuals who volunteer less.

At the within-person level, temporary deviations from a person's volunteering score are positively associated with simultaneous temporary deviations from their openness ( $rs$  of  $.015 - .026, p < .05$ ) and extraversion ( $rs$  of  $.013 - .035, p < .01$ ) trait scores at three measurement occasions. Temporary deviations from a person's volunteering score were negatively associated with simultaneous temporary deviations from their agreeableness ( $rs$  of  $-.018$  and  $-.013, p < .05$ ) and neuroticism ( $rs$  of  $-.016$  and  $-.011, p < .05$ ) trait scores at first and last measurement occasion only. There were no simultaneous temporary deviations of volunteering and conscientiousness trait scores.

At the within-person level, AR terms show higher stability for volunteering ( $\beta$ s of  $.219-.221$ ) compared to personality traits ( $\beta$ s of  $.108-.133$ ). That is, a random deviation from the individual's mean volunteer activity from one occasion to the next is more persistent than the within-person change in Big Five personality traits. Granger-Sims causality tests revealed that the model fit decreases significantly when constraining the CL path (c1) from volunteering to agreeableness ( $\Delta\chi^2(1) = 4.687, p < .05$ ), implying a small negative CL effect of volunteering  $\rightarrow$  agreeableness ( $\beta = -.020, p < .05$ ). No significant feedback effects are found.

However, adding an age group variable to the model reveals that this negative volunteering  $\rightarrow$  agreeableness CL effect (c1) is insignificant ( $\beta = -.021, p = .061$ ) in the middle age group (31-50 years). Just as large, but significant in this middle age group is the negative conscientiousness  $\rightarrow$  volunteering CL effect ( $\beta = -.021, p < .05$ ), which was not visible in the basic model. Further, on the within-person level, in the young (18-30 years) and older (51-75 years) age groups there are significant prospective effects (c1) from volunteering to extraversion ( $\beta$ s  $= .021, p < .05$ ), but not in the middle age group (see Supplement S6).

### Political Activities

Table 6 shows the standardized estimates, standard errors, and exact  $p$  values of the covariation of random intercepts and the within-person AR and CL paths for political activities in leisure time and all Big Five personality traits. Again, model fit statistics and results of Granger-Sims causality tests are reported.

At the between-person level, individuals engaged in political activities in their leisure time are more open ( $\psi = .078, p < .001$ ), more extraverted ( $\psi = .038, p < .001$ ), less agreeable ( $\psi = -.023, p < .001$ ), and less neurotic ( $\psi = -.041, p < .001$ ) than individuals who were involved less in political activities.

**Table 5. Volunteering Activities (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43554			N = 43634			N = 43604			N = 43652			N = 43661		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	0.220	0.013	0.000***	0.220	0.013	0.000***	0.221	0.013	0.000***	0.219	0.013	0.000***	0.219	0.013	0.000***
a2 (P)	0.124	0.011	0.000***	0.133	0.011	0.000***	0.117	0.011	0.000***	0.108	0.011	0.000***	0.123	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	0.005	0.008	0.539	-0.014	0.009	0.111	0.014	0.008	0.074	-0.020	0.009	0.030*	-0.004	0.008	0.634
c2 (P → A)	0.006	0.009	0.526	-0.012	0.008	0.146	0.006	0.010	0.531	-0.009	0.008	0.292	0.002	0.009	0.859
Covariances															
Random intercepts $\psi(X_i, Y_i)$	0.082	0.006	0.000***	-0.006	0.006	0.295	0.045	0.006	0.000***	0.002	0.006	0.777	-0.067	0.006	0.000***
Corr. change $\psi(lv_1, lu_1)$	0.026	0.006	0.000***	0.010	0.007	0.125	0.035	0.006	0.000***	-0.018	0.006	0.004**	-0.016	0.006	0.009**
Corr. change $\psi(lv_2, lu_2)$	0.017	0.006	0.002**	-0.005	0.006	0.430	0.015	0.006	0.009**	-0.002	0.006	0.773	0.001	0.006	0.802
Corr. change $\psi(lv_3, lu_3)$	0.010	0.006	0.078	-0.010	0.006	0.089	0.003	0.005	0.588	-0.006	0.006	0.332	-0.006	0.006	0.296
Corr. change $\psi(lv_4, lu_4)$	0.015	0.005	0.003**	-0.005	0.005	0.333	0.013	0.005	0.007**	-0.013	0.005	0.020*	-0.011	0.005	0.031*
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	23.992	(11)		31.502	(11)		48.242	(11)		34.466	(11)		22.480	(11)	
CFI / TLI	1.000	0.999		0.999	0.998		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.005	0.006		0.007	0.005		0.009	0.006		0.007	0.007		0.005	0.005	
AIC / BIC	416305	416592		423078	423364		415772	416059		424012	424298		419739	420026	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	24.369	(12)		34.042	(12)		51.425	(12)		39.153	(12)		22.707	(12)	
CFI / TLI	1.000	0.999		0.999	0.998		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.005	0.006		0.006	0.006		0.009	0.007		0.007	0.007		0.005	0.005	
AIC / BIC	416304	416581		423078	423356		415774	416051		424015	424292		419737	420015	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.377	(1)	0.540	2.540	(1)	0.111	3.183	(1)	0.074	4.687	(1)	0.030*	0.227	(1)	0.634
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	24.394	(12)		33.612	(12)		48.635	(12)		35.577	(12)		22.512	(12)	
CFI / TLI	1.000	0.999		0.999	0.999		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.005	0.006		0.006	0.006		0.008	0.006		0.007	0.006		0.005	0.004	
AIC / BIC	416304	416581		423078	423356		415771	416049		424011	424289		419737	420015	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.402	(1)	0.526	2.110	(1)	0.146	0.393	(1)	0.531	1.111	(1)	0.292	0.032	(1)	0.859



Step 4: Constrain all cross-lagged terms

$\chi^2$ (df)	24.505	(13)		34.567	(13)		51.539	(13)		39.160	(13)		22.956	(13)	
CFI / TLI	1.000	0.999		0.999	0.999		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.005	0.006		0.006	0.006		0.008	0.007		0.007	0.007		0.004	0.005	
AIC / BIC	416302	416571		423077	423346		415772	416041		424013	424282		419735	420005	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.512	(2)	0.774	3.065	(2)	0.216	3.297	(2)	0.192	46.942	(2)	0.096	0.476	(2)	0.788

Note. P = personality; LA = leisure activity; SE = standard errors; Corr. change = within-person correlated change; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; Associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

**Table 6. Political Activities (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43554			N = 43631			N = 43603			N = 43650			N = 43660		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	<b>0.187</b>	0.011	0.000***	<b>0.187</b>	0.011	0.000***	<b>0.186</b>	0.011	0.000***	<b>0.186</b>	0.011	0.000***	<b>0.187</b>	0.011	0.000***
a2 (P)	<b>0.125</b>	0.011	0.000***	<b>0.134</b>	0.012	0.000***	<b>0.117</b>	0.011	0.000***	<b>0.109</b>	0.011	0.000***	<b>0.123</b>	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	-0.002	0.007	0.803	-0.001	0.008	0.899	-0.010	0.007	0.154	0.002	0.008	0.798	-0.011	0.008	0.160
c2 (P → LA)	-0.003	0.010	0.725	-0.006	0.009	0.488	-0.006	0.010	0.516	0.005	0.009	0.571	-0.002	0.009	0.867
Covariances															
Random intercepts $\psi(X_i, Y_i)$	<b>0.078</b>	0.006	0.000***	-0.008	0.006	0.177	<b>0.038</b>	0.005	0.000***	<b>-0.023</b>	0.005	0.000***	<b>-0.041</b>	0.005	0.000***
Corr. change $\psi(lv_1, lv_1)$	<b>0.016</b>	0.006	0.013*	<b>0.026</b>	0.007	0.000***	<b>0.015</b>	0.006	0.011*	-0.008	0.007	0.231	<b>-0.026</b>	0.006	0.000***
Corr. change $\psi(lv_2, lv_2)$	0.006	0.006	0.316	0.001	0.006	0.833	0.003	0.006	0.620	-0.001	0.006	0.827	-0.001	0.006	0.918
Corr. change $\psi(lv_3, lv_3)$	0.003	0.006	0.544	<b>-0.018</b>	0.006	0.004**	-0.002	0.006	0.735	-0.011	0.006	0.084	-0.003	0.006	0.667
Corr. change $\psi(lv_4, lv_4)$	0.001	0.005	0.830	<b>-0.011</b>	0.006	0.060*	-0.000	0.005	0.962	-0.006	0.006	0.294	0.002	0.005	0.756
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	28.760	(11)		47.272	(11)		47.389	(11)		34.280	(11)		31.846	(11)	
CFI / TLI	0.999	0.999		0.999	0.997		0.999	0.997		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.006	0.005		0.009	0.007		0.009	0.006		0.007	0.006		0.007	0.006	
AIC / BIC	421351	421637		427985	428272		420832	421119		428907	429193		424831	425117	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	28.822	(12)		47.289	(12)		49.425	(12)		34.345	(12)		33.817	(12)	
CFI / TLI	1.000	0.999		0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.998	
RMSEA / SRMR	0.006	0.005		0.008	0.007		0.008	0.006		0.007	0.006		0.006	0.005	
AIC / BIC	421349	421626		427983	428261		420832	421110		428905	429183		424831	425109	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.062	(1)	0.803	0.016	(1)	0.899	2.038	(1)	0.154	0.066	(1)	0.798	1.971	(1)	0.160
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	28.884	(12)		47.753	(12)		47.811	(12)		34.601	(12)		31.874	(12)	
CFI / TLI	1000	0.999		0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.999	
RMSEA / SRMR	0.006	0.005		0.008	0.007		0.008	0.006		0.007	0.006		0.006	0.006	
AIC / BIC	421349	421626		427984	428262		420831	421108		428905	429183		424829	425107	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.124	(1)	0.725	0.481	(1)	0.488	0.421	(1)	0.516	0.321	(1)	0.571	0.028	(1)	0.868

Step 4: Constrain all cross-lagged terms

$\chi^2$ (df)	28.891	(13)		47.820	(13)		49.429	(13)		34.602	(13)		34.195	(13)	
CFI / TLI	1.000	0.999		0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.999	
RMSEA / SRMR	0.005	0.005		0.008	0.007		0.008	0.006		0.006	0.006		0.006	0.005	
AIC / BIC	421347	421616		427982	428251		420830	421099		428903	429172		424829	425098	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.131	(2)	0.937	0.547	(2)	0.761	2.039	(2)	0.361	0.3219	(2)	0.851	2.349	(2)	0.309

Note. P = personality; LA = leisure activity; SE = standard errors; Corr. change = within-person correlated change; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; Associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

At the within-person level, temporary deviations from a person's political activity score are positively associated with simultaneous temporary deviations from their openness ( $r = .016, p < .05$ ), conscientiousness ( $r = .026, p < .001$ ), and extraversion ( $r = .015, p < .05$ ) trait scores at the first measurement occasions. Temporary deviations from a person's political activity score were negatively associated with simultaneous temporary deviations from their neuroticism trait score ( $r = -.026, p < .001$ ) at the first measurement occasion and from their conscientiousness trait score ( $r$ s of  $-.011$  and  $-.018, p < .05$ ) at the third and fourth measurement occasions.

At the within-person level, AR terms show higher stability for political activity ( $\beta$ s of  $.186$ – $.187$ ) compared to personality traits ( $\beta$ s of  $.108$ – $.134$ ).

We found no within-person CL effects or feedback effects of political activities and Big Five personality traits.

Adding an age group variable to the model does not lead to different results (see Supplement S7).

### Artistic and Musical Activities

Results for RI-CLPM of artistic and musical activities and Big Five personality traits are shown in Table 7.

At the between-person level, individuals who are more artistically or musically active, (e.g.: making music, dancing, painting, etc.) in their leisure time are also considerably more open ( $\psi = .273, p < .001$ ), more extraverted ( $\psi = .059, p < .001$ ), more agreeable ( $\psi = .036, p < .001$ ), and less neurotic ( $\psi = -.041, p < .001$ ) but also less conscientious ( $\psi = -.030, p < .001$ ) than individuals who are less involved in artistic and musical activities.

At the within-person level, temporary deviations from a person's artistic and musical activity score are positively associated with simultaneous temporary deviations from their openness trait score ( $r$ s of  $.027$ – $.068, p < .001$ ). There are further simultaneous temporary deviations of artistic and musical activity from their extraversion trait scores ( $r$ s of  $.017$  and  $.031, p < .01$ ) at the first and third measurement occasions. There were no simultaneous temporary deviations of artistic and musical activity and conscientiousness, agreeableness, and neuroticism trait scores.

AR terms at the within-person level show that for artistic and musical activities ( $\beta$ s of  $.103$ – $.107$ ), random deviations from an individual's mean are less persistent than random deviations from an individual's mean of personality traits ( $\beta$ s of  $.108$ – $.134$ ).

An examination of CL paths shows that there are longitudinal within-person associations of artistic and musical activities with openness and extraversion, but not for other personality traits. Granger-Sims causality tests revealed that the model fit significantly deteriorates when constraining the cross-lagged path (c2) from openness to artistic and musical activity ( $\Delta\chi^2(1) = 3.936, p < .05$ ), implying a small positive openness  $\rightarrow$  artistic and musical activity effect ( $\beta = .019, p < .05$ ). Also, constraining the cross-lagged path (c2) from extraversion to artistic and musical activities ( $\Delta\chi^2(1) = 3.936, p < .05$ ) revealed a small positive extraversion  $\rightarrow$  artistic and musical activity effect ( $\beta = .020, p < .05$ ). Constraining all cross-lagged paths and comparing model fit to

the full model did not reveal any within-person feedback effects of artistic and musical activity and personality traits.

Adding an age group variable to the model revealed that the within-person AR term for artistic and musical activities is no longer significant in the youngest age group (18–30 years at t1). Further, the CL effect (c2) from openness  $\rightarrow$  artistic and musical activities ( $\beta$ s from  $.012$  to  $0.19, p > .05$ ) is now insignificant in all age groups. Additionally, the positive extraversion  $\rightarrow$  artistic and musical activity effect holds in the middle age group (31–50 years at t1) only. Not visible in the basic model is the positive prospective effect from neuroticism to artistic and musical activities ( $\beta = .055, p < .05$ ) among young adults. See Supplement S8 for details on age group results.

### Going-Out Activities

Table 8 shows the results of the RI-CLPM for going-out activities, such as going to movies, concerts, etc. and the Big Five personality traits. Again, model fit statistics and results of Granger-Sims causality tests are reported.

At the between-person level, individuals who go out more in their leisure time are also considerably more open ( $\psi = .136, p < .001$ ), more extraverted ( $\psi = .103, p < .001$ ), more agreeable ( $\psi = .036, p < .001$ ), less neurotic ( $\psi = -.101, p < .001$ ), less agreeable ( $\psi = -.029, p < .001$ ), and less conscientious ( $\psi = -.046, p < .001$ ) than individuals who go out less.

At the within-person level, temporary deviations from a person's going-out activity score are positively associated with simultaneous temporary deviations from their openness ( $r$ s of  $.016$ – $.025, p < .001$ ) and their extraversion ( $r$ s of  $.012$ – $.038, p < .05$ ) trait scores. Further, at first measurement occasions only, there were negative simultaneous temporary deviations of going-out activities with conscientiousness ( $r = -.048, p < .001$ ) and agreeableness ( $r = -.013, p < .05$ ). There were no simultaneous temporary deviations of going-out activities and neuroticism trait scores.

AR terms show that at the within-person level, random deviations from an individual's mean for going-out activities ( $\beta$ s of  $.104$ – $.109$ ) are less persistent than random deviations from an individual's mean of personality traits ( $\beta$ s of  $.109$ – $.136$ ).

An examination of CL paths shows that there are longitudinal within-person associations between going-out activities and conscientiousness, but not other personality traits. Granger-Sims causality tests revealed that the model fit significantly deteriorates when constraining the cross-lagged path (c1) to conscientiousness ( $\Delta\chi^2(1) = 4.542, p < .05$ ), implying a small positive CL effect of going-out activities  $\rightarrow$  conscientiousness ( $\beta = .019, p < .05$ ). Further, constraining all cross-lagged paths and comparing model fit to the full model ( $\Delta\chi^2(2) = 12.664, p < .01$ ) revealed feedback effects of conscientiousness and going-out activities. This means that a short-term individual boost in going-out activities or conscientiousness may impact going-out activities or conscientiousness or both by way of reciprocal effects.

**Table 7. Artistic and Musical Activities (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43562			N = 43638			N = 43609			N = 43656			N = 43667		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	<b>0.107</b>	0.011	0.000***	<b>0.104</b>	0.011	0.000***	<b>0.103</b>	0.011	0.000***	<b>0.104</b>	0.011	0.000***	<b>0.103</b>	0.011	0.000***
a2 (P)	<b>0.120</b>	0.011	0.000***	<b>0.134</b>	0.012	0.000***	<b>0.117</b>	0.011	0.000***	<b>0.108</b>	0.011	0.000***	<b>0.123</b>	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	0.005	0.008	0.553	-0.003	0.009	0.738	0.002	0.008	0.827	0.001	0.009	0.948	0.000	0.008	0.971
c2 (P → LA)	<b>0.019</b>	0.009	0.048*	0.008	0.008	0.333	<b>0.020</b>	0.010	0.035*	0.001	0.008	0.866	0.002	0.009	0.971
Covariances															
Random intercepts $\psi(X_i, Y_i)$	<b>0.273</b>	0.006	0.000***	<b>-0.030</b>	0.006	0.000***	<b>0.059</b>	0.005	0.000***	<b>0.036</b>	0.005	0.000***	<b>-0.039</b>	0.005	0.000***
Corr. change $\psi(lv_1, lv_1)$	<b>0.068</b>	0.006	0.000***	-0.009	0.006	0.132	<b>0.031</b>	0.006	0.000***	0.008	0.006	0.183	-0.011	0.006	0.073
Corr. change $\psi(lv_2, lv_2)$	<b>0.033</b>	0.006	0.000***	-0.003	0.006	0.574	0.007	0.005	0.180	0.002	0.006	0.770	0.009	0.006	0.137
Corr. change $\psi(lv_3, lv_3)$	<b>0.027</b>	0.006	0.000***	-0.011	0.006	0.066	<b>0.017</b>	0.006	0.002**	-0.011	0.006	0.070	-0.000	0.006	0.978
Corr. change $\psi(lv_4, lv_4)$	<b>0.039</b>	0.005	0.000***	0.010	0.005	0.065	0.006	0.005	0.199	0.010	0.006	0.073	0.001	0.005	0.840
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	67.754	(11)		34.270	(11)		42.798	(11)		33.821	(11)		24.016	(11)	
CFI / TLI	0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.011	0.010		0.007	0.006		0.008	0.006		0.007	0.007		0.005	0.006	
AIC / BIC	414196	414482		425967	426253		418630	418916		426873	427159		422904	423191	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	68.107	(12)		34.381	(12)		42.846	(12)		33.826	(12)		24.018	(12)	
CFI / TLI	0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.010	0.010		0.007	0.006		0.008	0.006		0.007	0.006		0.005	0.006	
AIC / BIC	414194	414472		425965	426243		418628	418906		426871	427149		422902	423180	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.353	(1)	0.553	0.112	(1)	0.738	0.048	(1)	0.827	0.004	(1)	0.948	0.001	(1)	0.971
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	71.690	(12)		35.207	(12)		47.264	(12)		33.850	(12)		24.080	(12)	
CFI / TLI	0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.998		1.000	0.999	
RMSEA / SRMR	0.011	0.010		0.007	0.006		0.008	0.007		0.006	0.007		0.005	0.006	
AIC / BIC	414198	414475		425966	426244		418632	418910		426871	427149		422902	423180	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	<b>3.936</b>	(1)	0.047*	0.938	(1)	0.332	<b>4.466</b>	(1)	0.035*	0.029	(1)	0.866	0.064	(1)	0.801



Step 4: Constrain all cross-lagged terms														
$\chi^2$ (df)	71.824	(13)		36.014	(13)		47.970	(13)		33.850	(13)		24.110	(13)
CFI / TLI	0.999	0.997		0.999	0.998		0.999	0.998		0.999	0.999		1.000	0.999
RMSEA / SRMR	0.010	0.010		0.006	0.006		0.008	0.007		0.006	0.007		0.004	0.006
AIC / BIC	414196	414465		425965	426234		418631	418900		426869	427138		422900	423169
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	4.069	(2)	0.131	1.744	(2)	0.418	5.173	(2)	0.075	0.029	(2)	0.986	0.094	(2) 0.954

Note. P = personality; LA = leisure activity; SE = standard errors; Corr. change = within-person correlated change; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; Associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

**Table 8. Going-out activities (LA) and Personality Parameter Estimates from the Random-Intercept Cross-Lagged Panel Model (RI-CLPM)**

	Openness			Conscientiousness			Extraversion			Agreeableness			Neuroticism		
Number of observations used	N = 43563			N = 43638			N = 43609			N = 43656			N = 43667		
Model parameters	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p	$\beta$	SE	p
Auto-regressive terms															
a1 (LA)	<b>0.109</b>	0.011	0.000***	<b>0.109</b>	0.011	0.000***	<b>0.107</b>	0.011	0.000***	<b>0.104</b>	0.011	0.000***	<b>0.107</b>	0.011	0.000***
a2 (P)	<b>0.123</b>	0.011	0.000***	<b>0.136</b>	0.012	0.000***	<b>0.115</b>	0.011	0.000***	<b>0.109</b>	0.011	0.000***	<b>0.122</b>	0.011	0.000***
Cross-lagged terms															
c1 (LA → P)	-0.005	0.008	0.493	<b>0.019</b>	0.009	0.033*	0.008	0.008	0.273	0.002	0.009	0.840	0.013	0.008	0.118
c2 (P → LA)	0.001	0.010	0.902	-0.013	0.009	0.150	0.008	0.010	0.433	0.003	0.009	0.708	0.001	0.009	0.889
Covariances															
Random intercepts $\psi(X_i, Y_i)$	<b>0.136</b>	0.006	0.000***	<b>-0.046</b>	0.006	0.000***	<b>0.103</b>	0.005	0.000***	<b>-0.029</b>	0.005	0.000***	<b>-0.101</b>	0.005	0.000***
Corr. change $\psi(lv_1, lv_1)$	<b>0.025</b>	0.006	0.000***	<b>-0.048</b>	0.006	0.000***	<b>0.038</b>	0.006	0.000***	<b>-0.013</b>	0.006	0.036*	-0.030	0.006	0.061
Corr. change $\psi(lv_2, lv_2)$	<b>0.016</b>	0.006	0.005**	0.006	0.006	0.371	<b>0.018</b>	0.006	0.001**	0.003	0.006	0.625	-0.002	0.006	0.729
Corr. change $\psi(lv_3, lv_3)$	0.003	0.006	0.647	-0.005	0.006	0.420	<b>0.015</b>	0.006	0.008**	-0.003	0.006	0.677	0.000	0.006	0.978
Corr. change $\psi(lv_4, lv_4)$	<b>0.025</b>	0.005	0.000***	0.008	0.006	0.144	<b>0.012</b>	0.005	0.014*	-0.001	0.006	0.883	0.000	0.005	0.934
Granger-Sims Causality Tests															
Step 1: Derive Fit of Full Model															
$\chi^2$ (df)	40.384	(11)		111.86	(11)		70.654	(11)		31.548	(11)		49.127	(11)	
CFI / TLI	0.999	0.998		0.997	0.991		0.998	0.996		0.999	0.998		0.999	0.997	
RMSEA / SRMR	0.008	0.007		0.014	0.014		0.011	0.010		0.007	0.007		0.009	0.009	
AIC / BIC	420716	421003		428056	428342		420309	420596		429160	429447		424569	424751	
Step 2: Constrain LA → P (c1)															
$\chi^2$ (df)	40.854	(12)		116.40	(12)		71.856	(12)		31.589	(12)		51.577	(12)	
CFI / TLI	0.999	0.998		0.996	0.992		0.998	0.996		0.999	0.998		0.999	0.997	
RMSEA / SRMR	0.007	0.007		0.014	0.015		0.011	0.010		0.006	0.007		0.009	0.009	
AIC / BIC	420715	420992		428059	428337		420308	420586		429158	429436		424570	424746	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.470	(1)	0.493	<b>4.5422</b>	(1)	0.033*	1.202	(1)	0.273	0.041	(1)	0.840	2.4505	(1)	0.118
Step 3: Constrain P → LA (c2)															
$\chi^2$ (df)	40.399	(12)		113.93	(12)		71.270	(12)		31.689	(12)		49.146	(12)	
CFI / TLI	0.999	0.998		0.997	0.992		0.998	0.996		0.999	0.998		0.999	0.997	
RMSEA / SRMR	0.007	0.007		0.014	0.015		0.011	0.010		0.006	0.007		0.008	0.009	
AIC / BIC	420714	4209925		428056	428334		420308	420585		429158	429435		424567	424743	
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.015	(1)	0.902	2.064	(1)	0.151	0.616	(1)	0.433	0.141	(1)	0.708	0.0194	(1)	0.889

Step 4: Constrain all cross-lagged terms													
$\chi^2$ (df)	41.106	(13)		124.52	(13)		71.958	(13)		31.690	(13)		52.019 (13)
CFI / TLI	0.999	0.998		0.996	0.992		0.998	0.997		0.999	0.999		0.999 0.997
RMSEA / SRMR	0.007	0.007		0.014	0.015		0.010	0.010		0.006	0.007		0.008 0.009
AIC / BIC	420713	420982		428065	428334		420306	420575		429156	429327		424568 424739
$\chi^2$ Difference Test (diff <sub>df</sub> ) p	0.7227	(2)	0.697	<b>12.664</b>	(2)	0.002**	1.304	(2)	0.521	0.142	(2)	0.932	2.893 (2) 0.235

Note. P = personality; LA = leisure activity; SE = standard errors; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; BIC = Bayes information criterion; Associations are coded to match paths in [Figure 1](#). All variables were standardized to have a mean of zero and a standard deviation of one. Significant parameters and chi-square differences are bold. \*p <.05, \*\*p< .01, \*\*\*p<.001

Adding an age group variable to the model revealed that the within-person AR term for going-out activities is no longer significant in the youngest age group. Thus, random deviations in going-out activities are not persistent to the next occasion in young adults. The reported positive CL effect of going-out activities on conscientiousness do not hold for the middle age group. Instead, there is a significant prospective effect of extraversion on going-out activities in the middle age group only that was not visible in the basic model. See Supplement S9 for details on age grouping results for going-out activities.

## Summary of Results

At the between-person level, we found comparatively strong positive correlations between openness and the various leisure activities as well as overall participation in leisure activities ( $\psi = [.078; .273]$ ). Conscientiousness and the various leisure activities and the overall participation index have either no significant or small negative correlations ( $\psi = [-.046; -.015]$ ). Higher extraversion is associated with a higher overall level of participation in leisure activities and with a higher frequency of all of the leisure activities investigated ( $\psi = [.038; .132]$ ). Agreeableness is not significantly correlated with overall participation in leisure activities at the between-person level, but it is negatively correlated with physical, political, and going-out activities and positively correlated with socializing, artistic, and musical activities. Neuroticism and the various leisure activities and the overall participation index have small negative correlations ( $\psi = [-.120; -.039]$ ).

At the within-person level, temporary deviations from a person's openness trait score are positively associated with simultaneous temporary deviations from their overall participation in leisure activities, and from their socializing, artistic, and musical activities at all measurement occasions. The same applies to the relationship between fluctuations in extraversion with simultaneous temporary deviations in overall participation in leisure activities, socializing activities, and going-out activities. Temporary deviations from a person's physical activities, volunteering, and political activities are not unambiguously associated with simultaneous deviations in personality traits. That is, there are only a few significant correlations at some measurement points for the aforementioned leisure activities with personality traits; see [Tables 2–8](#).

AR terms show higher stability for the overall level of participation in leisure activities, physical activities, volunteering, and political activities, compared to personality traits. This means that the persistence of a random deviation from an individual's mean from one occasion to the next appears to be larger for the aforementioned leisure activities than for personality traits. For socializing, artistic and musical activities, and going-out activities, AR terms show lower persistence of a random deviation than for personality traits; see [Tables 2–8](#).

The CL terms reflect the estimated change in the individual's leisure activity due to an unexpected change in a personality trait on the previous occasion or vice versa. For a summary of results on within-person cross-lagged effects for the full sample and for the age groups, see [Table 9](#).

## Discussion

In this study, we tested whether temporary fluctuations in leisure activities around an individual's mean level have prospective effects on fluctuations in the Big Five personality traits and vice versa. Finding such within-person feedback effects would contribute to comprehensive theories of personality development. Based on the TESERRA framework (Wrzus & Roberts, 2017), we assumed that frequent leisure activities could be triggering situations in repeated TESERRA sequences.

Data came from the German Socio-Economic Panel (SOEP) study, which includes four waves of personality and leisure activity assessments over a 13-year period in a nationally representative sample of 55,790 individuals, aged 18 to 87 years. Using random-intercept cross-lagged panel models, we disentangled between-person and within-person variance and established temporality and directionality to personality development and participation in leisure activities.

In the following paragraphs, we discuss to what extent the specific leisure activities investigated and the overall participation in leisure activities drive personality development (and vice versa). Additionally, we project the results onto the TESSERA framework.

### Overall Participation in Leisure Activities

Derived from earlier, mainly cross-sectional studies, we suspected positive transactions between overall participation and openness and extraversion, and vice versa. Although we found a strong association between openness and overall participation on the between-person level, and simultaneous temporary deviations at the within-person level, we found no cross-lagged effects for openness. In other words, we found that increasing an individual's level of involvement in leisure activities did not lead to a change in openness.

However, we found within-person effects for extraversion. As hypothesized, we found feedback effects for overall participation in leisure activities and extraversion. That is, temporary fluctuations in overall leisure activity around an individual's mean level had prospective effects on fluctuations in extraversion and vice versa. A close relationship between the level of overall leisure activity and extraversion was already reported by Furnham (2004), who attributed this to higher sensation-seeking by extraverts. Interestingly, the within-person cross-lagged effect of a change in overall participation in leisure activities on a change in extraversion was significant for the young and older age groups only. The opposite prospective effect, i.e., the effect of a change in extraversion on a change in overall participation, was found to be significant in the middle age group only. This suggests that fluctuations in overall leisure activity only show an effect on personality when rank-order stability is smaller, that is, in young adulthood and in old age (Roberts & DelVecchio, 2000; Specht et al., 2011). In middle adulthood, when rank-order stability in extraversion is highest, short-term fluctuations in extraversion may cause changes in overall participation in leisure activities but not vice versa.

Table 9. Summary of Within-Person Cross-Lagged Effects for Big Five and Leisure Activities Across Age Groups in RI-CLPM

		Openness				Conscientiousness				Extraversion				Agreeableness				Neuroticism			
		all	young	middle	old	all	young	middle	old	all	young	middle	old	all	young	middle	old	all	young	middle	old
Overall Participation																					
LA → P										<b>+</b>	+		+								
P → A												+									
Physical Activities																					
LA → P																					
P → A														+		+					
Socializing																					
LA → P						+				<b>+</b>	+	+	+								
P → A					+					<b>+</b>		+	+					-			-
Volunteering																					
LA → P											+		+	-	-		-				
P → A								-													
Political Activities																					
LA → P																					
P → A																					
Artistic & Musical Activities																					
LA → P								-													
P → A		+								+		+							+		
Going-out activities																					
LA → P						+	+		+												
P → A												+									

Note. P = personality; LA = leisure activity; + = positive cross-lagged effect, significant on p-level <.05; - = negative cross-lagged effect, significant on p-level <.05; bold+/- = cross-lagged effect in full-sample model; non-bold +/- = cross-lagged effect in models with age-groups; grey shading = feedback effect; young = between 18 and 30 years old at T1, middle = between 31 and 50 years old at T1, older = between 51 and 75 years old at T1 in 2005

## Physical Activities

We hypothesized positive prospective effects of an increase of conscientiousness and an increase of openness on physical activity. Further, we suspected a negative effect of increase of agreeableness on physical activity. The existing literature provided no evidence of an effect of changes in physical activity on personality change.

Indeed, we did not find any effect of the change in frequency of physical activity on the personality traits of an individual. However, contrary to expectations, we also did not find any cross-lagged effect of changes in conscientiousness and openness on an individual's level of physical activity. Regarding agreeableness, the effect was different than expected: a random short-term increase in agreeableness on one occasion led to an increase in physical activity (compared to an individual's usual level) on a later occasion and not to a decrease in playing sports. Comparing age groups suggested that this positive prospective effect of agreeableness on physical activity was most prominent in middle adulthood.

## Socializing

Previous studies have demonstrated that socializing is positively associated with extraversion and agreeableness. Based on that research, we hypothesized that an increase in the frequency of private socializing may result in an increase in extraversion and agreeableness and vice versa.

The hypothesis on agreeableness was not confirmed. After estimating between-person differences, we still found simultaneous temporary deviations between socializing and agreeableness in the same directions but found no cross-lagged effects for socializing and agreeableness at the within-person level. It may be that the frequency of socializing by itself is not a trait-triggering situation for agreeableness. Hence, it could conceivably be hypothesized that only meetings with emotionally secure attachment figures are state-relevant in the sense of the TESSERA framework. However, we did not capture the valence or other characteristics of leisure activities in this study.

The results confirmed our hypothesis that an increased frequency of socializing drives an increase in extraversion (and vice versa). Regarding extraversion, we found the hypothesized reciprocal prospective within-person effects of socializing and extraversion. That is, temporary fluctuations in socializing activities, such as meeting friends and relatives, around an individual's mean level had prospective effects on fluctuations in their extraversion and vice versa.

One unexpected finding of this study regarding socializing effects on personality change was that there was a positive within-person cross-lagged effect on conscientiousness. This means that if an individual's social activity was higher than usual on one occasion, he or she was more conscientious on the next occasion. However, this result should be interpreted with caution, because it did not hold after adding age groups to the model. The within-person-correlated change was also inconsistent: partly positive and partly negative. The prospective effect of socializing on conscientiousness should be addressed again in future investigations. It may be a random effect.

Further, we found effects of personality change on change in social activity: Random increases in neuroticism led to less frequent socializing in the future, especially among older adults. Also, exclusively in old age, increases in openness led to more frequent social activities.

In general, we found that in later adult life, when social situations may need to be pursued more actively, extraversion, openness, and neuroticism were more crucial for the development of future socializing behavior than in young adulthood. A possible explanation for this might be that the persistence of fluctuations, that is, the within-person autoregressive effect of socializing was much stronger in the young and middle age groups than in the older age group.

## Volunteering

Based on earlier research investigating between-person associations of public social activity, we hypothesized that changes in an individual's volunteering behavior may trigger changes in extraversion and agreeableness trait levels and vice versa. Regarding extraversion our hypothesis was partially confirmed. We found within-person cross-lagged effect of volunteering on extraversion, but in the young and older age groups only. This means that when young and older adults engaged in more volunteer work than usual, their extraversion was prospectively higher than their trait level. However, an increase in extraversion did not result in more volunteer work on a subsequent occasion.

There was a similar one-sided effect of volunteering on agreeableness. Contrary to our hypothesis, we found a negative (not a positive) within-person cross-lagged effect of volunteering on agreeableness. This means that if an individual volunteered more than usual on one occasion, this caused a decline in his or her agreeableness in the next occasion. This rather contradictory result may have been due to an increase in the level of volunteer work, far above the usual level, creating a burden for the individual. The resulting stress may in turn have led to lower agreeableness.

A prospective effect of personality change on volunteering was found for conscientiousness when adding age groups only. That is, in middle adulthood, people who became more conscientious than usual subsequently reduced their involvement in volunteering.

From these results, we can infer that volunteering may influence agreeableness and extraversion, but that it tends not to in middle adulthood. Conversely, higher conscientiousness had a significant negative influence on volunteering behavior in middle adulthood only. Since age is mainly a proxy for unknown confounders for development, it could conceivably be hypothesized that transactions between volunteering and personality were moderated by involvement in professional life. Further research should be undertaken to investigate this question.

## Political Activities

We hypothesized that there may be a positive transaction between the change in political activity and the change in agreeableness and extraversion. Contrary to expectations, we found no within-person cross-lagged or feedback effects of political activities in leisure time and any of the Big Five personality traits. This result may be partly explained by the

fact that the mean and variance for political activities were very low. The great majority of the sample was never or seldom politically active. Thus, the distribution was skewed, and prospective effects were difficult to find. Surprisingly, especially among young and middle-aged adults, autoregressive effects at the within-person level in political activities (i.e., short-term fluctuations) were up to twice as stable as changes in personality traits.

### **Artistic and Musical Activities**

We expected that changes in the frequency of artistic and musical activities may trigger changes in openness and vice versa. This hypothesis was only partially confirmed. Random increases in openness led to prospective increases in artistic and musical activities. We found no effect, however, of changes in artistic and musical activities on an individual's openness. At first glance, this appears somewhat contradictory to earlier findings by Schwaba et al. (2018), who reported that increases in cultural activity precipitate increases in openness and vice versa. However, their definition of cultural activity involves relatively passive artistic and musical activities, such as going to the theater or opera or visiting museums, whereas our measure covered active behaviors, such as making music, dancing, theater, painting, and photography. Further, the results reported by Schwaba et al. (2018) may have been confounded by between-person effects. Additionally, the time scale is important for investigating causal processes. The measurement occasions in the current study were four years apart, whereas participants in the research of Schwaba et al. (2018) completed the survey every year or every second year. In the present study, we also found simultaneous temporary deviation in the same direction of openness and artistic and musical activity within persons. This points to shorter cause-effect relationships.

Unexpectedly, we found a negative effect of changes in artistic and musical activity on conscientiousness in middle adulthood. That is, if a middle-aged adult was doing more arts and music in his or her leisure time than usual, he or she might be less conscientious prospectively. Thus, artistic and musical activities in leisure time may drive personality development only in this specific setting.

Further prospective effects of personality change on artistic and musical activities appear to be age-group-specific as well. In this study, we found a significant positive effect of an increase in extraversion on artistic and musical activity in middle adulthood only. In young adulthood, when within-person fluctuations in artistic and musical activity were less persistent, increasing neuroticism led to more artistic and musical activity, i.e., creativity. This last finding was consistent with that of Speaks (2013), who reported a positive association between neuroticism and arts and crafts in their sample of university students.

### **Going-Out Activities**

To our knowledge, there are no other studies to date on what we refer to as "going-out activities," such as going to the movies, going to concerts, dancing, clubbing, or attending sporting events, in relation to the Big Five personality traits. We hypothesized that going-out activities may show

positive transactions between extraversion and openness to experiences and vice versa.

Contrary to expectations, at the within-person level, we found no cross-lagged effects for openness and going-out activities. Partly in line with our hypothesis, positive fluctuations in extraversion led to increased going-out activities in middle adulthood. However, changes in going-out activities had no prospective effects on extraversion.

Surprisingly, we found a positive cross-lagged effect of going-out activities on conscientiousness, but not in middle adulthood. This means that the increase in the individual's conscientiousness may have been due to an increase in the individual's going-out activity on the previous occasion, but only in young adulthood and old age. This result is relatively counterintuitive. According to the TESSERA framework (Wrzus & Roberts, 2017), a possible explanation might be that going-out activities trigger situations in which conscientiousness develops (e.g., planning activities, organizing a group to go out with, etc.), but only in early and later adulthood.

### **How Do our Findings Relate to the TESSERA Framework of Personality Development?**

Applying the TESSERA framework on personality development in adulthood (Wrzus & Roberts, 2017) to our results, overall participation in leisure activities and the activities of socializing (i.e., meeting friends, family, acquaintances etc.) and volunteering may be triggering situations for extraversion development. According to the theory, extraversion may change because a triggering situation is repeatedly perceived as trait-relevant and thus elicits a relevant state—e.g., talking at length about one's own experiences—that does not correspond to the actual low extraversion, but nevertheless elicits a positive reaction: e.g., people are grateful or interested in meeting again. The same mechanism can be applied to other traits and situations: Socializing and going-out activities may be triggering situations for conscientiousness development. And a change in agreeableness may be triggered by a change in volunteering, according to our results.

According to this framework, internal reflective or associative processes transform repeated TESSERA sequences into long-term personality development. A note of caution should be added here since we did not assess these cognitive processes. Our measure of leisure activity only addresses frequency. However, cognitive and emotional aspects of leisure activities such as how rewarding they are, how voluntary they are, or how enjoyable they are could have an influence on related personality changes as well. In the above-described relationship between socializing and extraversion, for example, it would be decisive that the reaction of the environment is perceived as positive.

We found no prospective effects of any of the leisure activities investigated on openness or neuroticism. The question of where inter-individual differences in the covarying expression of both traits and leisure activities come from therefore remains. Between-person differences must be the result of differential intra-person developments that took place at some point in the past. However, the leisure activities and the overall participation examined here do not ap-

pear to be triggering situations in the sense of the TESSERA framework (Wrzus & Roberts, 2017) for the development of openness to experience and neuroticism.

### Limitations and Future Directions

In this study, we used four waves of longitudinal survey data from a national representative sample from Germany with more than 55,000 participants who were followed over 13 years, from 2005 to 2017. This allowed us to investigate longitudinal associations between Big Five personality traits and the frequency of leisure activities over time. However, our study is not without limitations.

The measure of frequency of leisure activity used in the current study was based on a rather unprecise four-point scale, which may not have been sensitive enough to capture the full extent of within-person change (Ram & Gerstorf, 2009). This may have led to an underestimation of effects. Moreover, personality traits were assessed with only three items each and did not allow for more specific, facet-level analyses, which could have revealed a more fine-grained pattern of results.

As a limitation of our design, we note that the assessment intervals in our study—every four years—were rather long. Frequent and well-timed personality assessments are necessary to understand how trait changes unfold in the context of experiences (Bleidorn & Hopwood, 2019; Luhmann et al., 2014; Schwaba et al., 2018). However, the magnitude of within-person effects of personality interrelations varies depending on the time interval under consideration (see Müller et al., 2018). Our results should therefore be interpreted with caution. Future inquiries may shed further light on personality processes by conducting assessments at different time scales.

It is also important to bear in mind the possible alpha inflation (type-I error) due to multiple testing in this study. It may be that we are reporting effects that do not actually exist. However, we decided not to use a stricter significance threshold than  $p < .05$ . Due to the long measurement intervals and the small effects that can therefore be expected, the risk of overlooking an effect (type-II error) that can be examined more thoroughly in future studies would have been high.

Our results on age effects should also be interpreted with caution. We obtained a first impression of the impact of age through model fit testing with and without constraints across age groups, but the mechanisms in the different age groups should be investigated in more detail in further studies.

Age and developmental contexts could potentially inform the relationship between leisure activities and personality change, but so could other factors. To better understand the mechanisms underlying the link between change in participation in leisure activities and change in personality, future research might utilize in-vivo data on thoughts and feelings centered on the environmental changes (e.g., Wrzus & Roberts, 2017). This would enable them to examine the relevance of leisure activity characteristics beyond their frequency, such as voluntariness, enjoyment, and consequences and reactions.

### Conclusion

The purpose of the current study was to examine the extent to which within-person changes in overall participation in leisure activities, and participation in a variety of specific leisure activities lead to prospective changes in an individual's Big Five personality traits, and whether changes in personality elicit prospective changes in a person's leisure activities.

Taken together, by applying RI-CLPM to four waves of 13-year longitudinal data from the Socio-Economic Panel (SOEP) study, the present study has shown that at the between-person level, the leisure activities investigated as well as the overall level of participation are most strongly associated with openness. However, at the within-person level, we found prospective feedback effects for extraversion with socializing and overall participation only. We found first evidence that some within-person cross-lagged effects of specific leisure activities with certain personality traits occur in certain age groups only. For example, a cross-lagged effect of volunteering on a prospective increase in extraversion was significant in young and old age groups only.

Overall, this study adds support to the idea of the TESSERA framework, that repetitive trait-triggering situations can lead to personality change. However, for openness and neuroticism, we could not identify triggering leisure activities in the current study. To develop a broader picture of personality trait-triggering leisure situations, additional studies will be needed that investigate more leisure experiences in connection with personality changes on a shorter time scale.

### Contributions

All authors contributed to the study concept and design. Statistical analyses were performed by Julia Sander and Paul Schumann. Results were discussed with David Richter Paul Schumann and Jule Specht. Julia Sander drafted the manuscript, and all remaining authors provided critical revisions. All authors approved the final version of the manuscript.

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### Competing interests

The authors declare that they have no conflicts of interest with respect to their authorship or the publication of this article. Any opinions, findings, and conclusions ex-



pressed herein are those of the authors and do not necessarily reflect the views of the institute conducting the SOEP survey.

### Supplemental material

Table S1-S9 can be found on the Open Science Framework (OSF) website: [https://osf.io/fdxzp/?view\\_only=eaffa966ffe14e7c8a4ccb5ace76ace6](https://osf.io/fdxzp/?view_only=eaffa966ffe14e7c8a4ccb5ace76ace6)

Supplement S1 and S3-S9. xlsx

Supplement S2. PDF

### Data accessibility statement

Due to strict provisions of German data protection law, we cannot make the data publicly available. However, the

data are available from German Socio-Economic Panel at the German Institute for Economic Research (for requests, please contact [soepmail@diw.de](mailto:soepmail@diw.de)). The scientific use files of the data with anonymous microdata are made available free of charge to universities and research institutes for research and teaching purposes. For further information, contact the SOEP Hotline at either [soepmail@diw.de](mailto:soepmail@diw.de) or +49-30-89789-292.

[http://www.diw.de/documents/dokumentenarchiv/17/diw\\_01.c.88926.de/soep\\_application\\_contract.pdf](http://www.diw.de/documents/dokumentenarchiv/17/diw_01.c.88926.de/soep_application_contract.pdf).

Hypotheses were not preregistered. Analysis scripts can be found on the Open Science Framework (OSF) website: [https://osf.io/fdxzp/?view\\_only=eaffa966ffe14e7c8a4ccb5ace76ace6](https://osf.io/fdxzp/?view_only=eaffa966ffe14e7c8a4ccb5ace76ace6)

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### Peer Review and Communication History

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### Supplement S2

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